MODEL 420-S-43
TRANSMISSION LEVE
TEST SET

WAVETEK

9045 BALBOA AVENUE, SAN DIEGO, CALIFORNIA

MODEL 420-S-438
TRANSMISSION LEVEL TEST SET

WAVETEK
Box 651, San Diego, Calif., 714-279-2200

7/74

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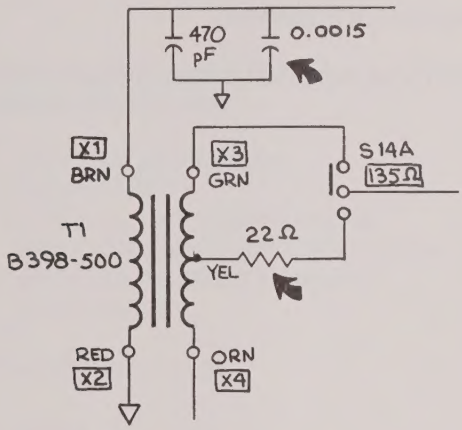
MODEL 420-S-438

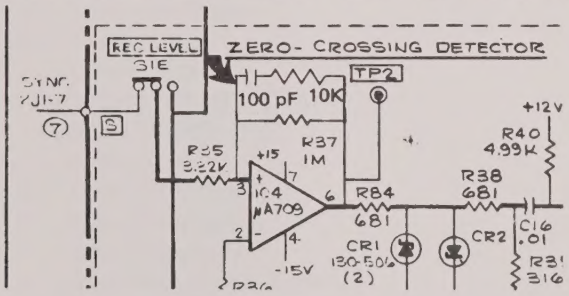
ADDENDUM

The following changes have been made to the Model 420-S-438.

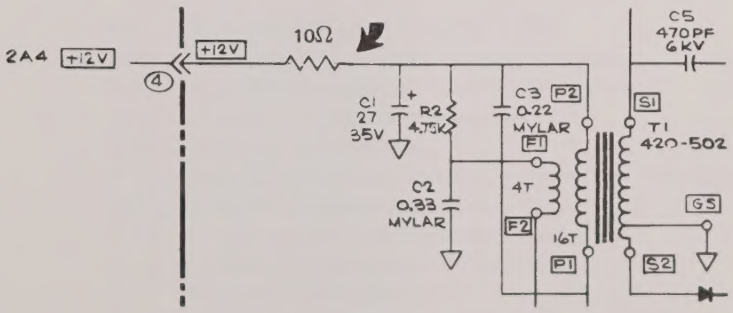
1. On the transmitter main board, assembly D398-005 and schematic D398-205, 0.0015 MFD and 470 pF capacitors have been added across transformer T1 and a 22Ω resistor in the 135Ω tap of the output transformer T1.



2. On the receiver main board, assembly D398-006 and schematic D398-206, a series network consisting of a 100 pF and 10 kΩ has been placed across the feedback resistor R37 (1M) of the zero crossing detector.



3. On the receiver high voltage supply board, assembly D420-019 and schematic D420-219, a 10Ω resistor has been inserted in the +12 Vdc supply line to the high voltage oscillator.



4. On the transmitter main board (D398-005), R118 has become a selected value (12 kΩ to 18 kΩ) to center R114 pot (135Ω 0 dBm). Selection must be done after the 600Ω 0 dBm and 900Ω 0 dBm level adjustments have been set.

5. Change paragraph 3.6 heading (page 3-17) and the Contents (page ii):

   Was: CABLE LENGTH MEASUREMENT

   Should Be: CABLE LENGTH MEASUREMENT AND CAPACITANCE MEASUREMENT OF LOADED LINE

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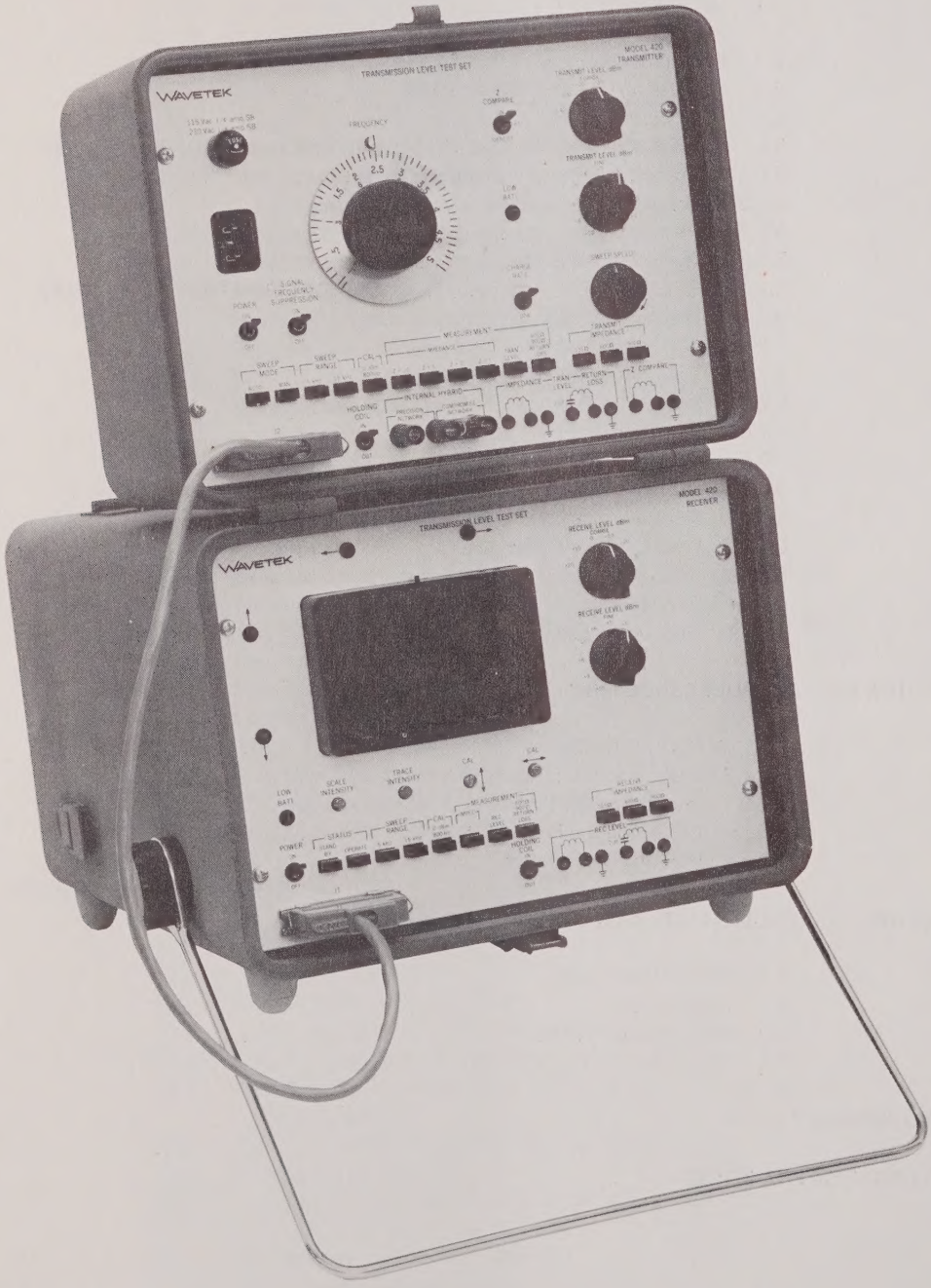


Figure 1-1. Model 420-S-438 Transmission Level Test Set

SECTION 1
GENERAL DESCRIPTION

1.1 INTRODUCTION

This manual describes the Model 420-S-438 Transmission Level Test Set (referred to as Model 420), and gives methods for using it to measure:

- Impedance
- Transmission Levels
- Transmission Losses
- Return Loss, Balance
- Cable Length

The functions of controls, jacks, and indicators on the front panels of the transmitter and receiver units are also described. This manual is a practical guide in the use of the instrument. It does not develop the theory underlying the various measurements.

1.2 DESCRIPTION

The Model 420 test set consists of three units, two of which are major: the transmitter unit, and the receiver unit (see Figure 1-1); the rear section of the test set is the power supply unit for the receiver.

The transmitter is a voltage controlled oscillator, which transmits a sine wave from 50 to 15,000 Hz. The output level can be set in 1 dB steps from −50 dBm to +10 dBm into either 135Ω, 600Ω, or 900Ω. The frequency may be set to a single fixed value, swept manually, or swept automatically. The sweep rate may be varied from 10 to 30 sweeps per minute, and the frequency may be swept from 50 to 5000 Hz, or from 150 to 15,000 Hz. The transmitter also contains a very sensitive hybrid network that serves as an impedance bridge in the return loss mode.

The receiver is a cathode ray oscilloscope arranged to show impedance, level, or return loss on the vertical scale as a function of frequency on the horizontal scale. When the received signal varies in frequency, the spot moves horizontally to indicate the frequency, and vertically to indicate the corresponding level or impedance. The result is a graph of the measured level versus frequency.

1.3 TRANSMITTER SPECIFICATIONS

1.3.1 Output

Sine wave output with two selectable frequency ranges:
50 Hz to 5 kHz;
150 Hz to 15 kHz.
Output level adjustable from +10 dBm to −50 dBm in 1 dBm steps.

1.3.2 Output Impedance

135Ω, 600Ω, or 900Ω balanced.

1.3.3 Operating Modes

Cal: Instrument generates milliwatt source (800 Hz, 0 dBm).
Auto-Sweep: The transmitter generates a signal which is swept over the selected frequency range 50 Hz to 5 kHz, or 150 Hz to 15 kHz. Sweep rate is variable with front panel control.
Manual Sweep: Instrument frequency is controlled manually by dial.
Impedance: 100Ω to 9000Ω in 4 ranges.
Return Loss: To −60 dBm.

1.3.4 Frequency Response

50 Hz to 15 kHz . . . . . ±0.2 dB

1.3.5 Sine Distortion

50 Hz to 15 kHz (at 0 dBm) . . . . . ±1%

1.3.6 Internal Hybrid Network

600Ω or 900Ω, resistive, with 600Ω and 2.15 μF or 900Ω and 2.15 μF compromise network removable by front panel ground strap. Terminals available for precision external network.

1.3.7 Holding Coil

Switchable in and out. Approximately 2 henrys with 170Ω. 100 mA current capability.

1.3.8 Attenuator Accuracy

50 Hz to 15 kHz . . . . . ±0.1 dB

1.4 RECEIVER/DISPLAY SPECIFICATIONS

1.4.1 Receiver Level

+33 dBm to −50 dBm.

1.4.2 Input Impedance

135Ω, 600Ω, or 900Ω, selected by front panel pushbutton.

1.4.3 Calibration

Transmitter calibration signal of 800 Hz, 0 dBm. Receiver adjusted by two front panel controls to 1 kHz at 0 dBm.

1.4.4 Frequency Response

50 Hz to 15 kHz . . . . . ±0.2 dB

1.4.5 Holding Coil

Switchable in and out. Approximately 2 henrys with 170Ω.

1.4.6 Display

Correct scale is automatically displayed when measurement mode is selected. CRT screen is 2-1/4 in. high, 3-3/8 in. wide. Display error: ±0.2 dB.

1.4.7 Impedance Comparison

Allows two impedance versus frequency plots to be displayed for comparison. One trace is continuous and the other is dotted for easy identification.

1.4.8 Attenuator Accuracy

50 Hz to 15 kHz . . . . . ±0.1 dB

1.5 MECHANICAL SPECIFICATIONS

1.5.1 Dimensions

12 in./30.5 cm long; 9 in./22.9 cm high; 23 in./58.4 cm deep.

1.5.2 Weight

Less than 30 lb/14 kg in environmental aluminum case; 36 lb/16 kg with batteries.

1.5.3 Power

115 V to 250 V; 50 Hz to 400 Hz. Less than 30 watts.

1.5.4 Battery Power

Provides rechargeable ni-cad battery power for transmitter and receiver. Transmitter battery life is 8 hours of continuous operation with a 14 hour charge. Receiver battery life is 2 hours continuous operation with a 14 hour charge.

Note: Standby status provided to extend the receiver operating time. "Battery low" lamp indicates battery at low level. Simultaneous charge and operation possible.

1.6 REFERENCES

In this manual are some typical requirements in terms of the pointer-on-scale readings and methods of applying these requirements to the graphic display of the Model 420. The theory underlying the tests, and additional background, are contained in the books and technical papers listed at the back of this manual. Selected Bell System Practices which deal with transmission measurements for which the Model 420 Transmission Level Test Set is particularly useful are also listed.

SECTION 2
PREPARATION FOR USE

2.1 SETUP

The Model 420, closed for travel, is illustrated in Figure 2-1. The set consists of three boxes: the transmitter, the receiver, and the receiver power supply. They are mechanically connected by slip hinges and toggle fasteners. They can be separated when necessary. The connecting cables and power cords are contained in space between the receiver and power supply. To set up the instrument for measurements, proceed as follows.

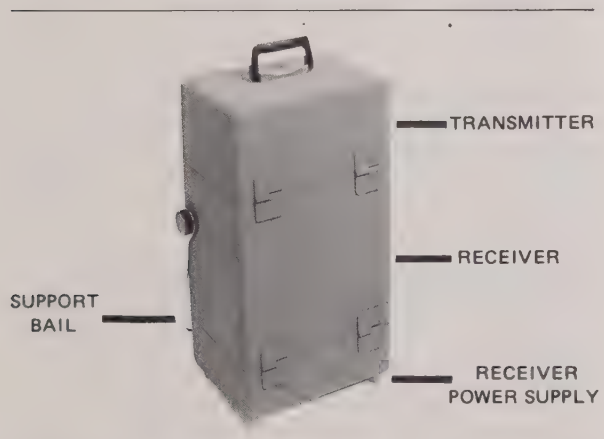


Figure 2-1. All Components Fastened Together for Carrying

2.1.1 Receiver, Power Supply, and Connecting Cables

(1) Set the Model 420 on the transmitter end.

(2) Release the toggle fastener of the receiver power supply, and swing the power supply on its hinges.

(3) Take out the connecting cable, power cords, and other accessories.

(4) Set the AC LINE VOLTAGE switch to the proper value: 115 V or 230 V. (See Paragraph 2.1.2, Step 6.)

(5) Set the CHARGE RATE switch to HIGH.

(6) Inspect the three fuses to assure that none are blown.

(7) Test the power plug from power supply to receiver to assure that it is tightly locked.

(8) Close and fasten the power supply.

2.1.2 Transmitter and Receiver

(1) Stand the set in a vertical position as shown in Figure 2-1.

(2) Loosen the knobs for the support bail, and unscrew them until the bail is free to move.

(3) Flex the bail ends away from the case and adjust the position of the bail to any of several detents for the desired position of the set during measurement; tighten the knobs enough to hold the bail in the detent. Tip the set to rest on the bail.

(4) Release the transmitter/receiver fastener.

(5) Rotate the transmitter about its hinges until the transmitter case rests against the receiver case.

(6) Both the transmitter and receiver are set for 115 V at the factory unless otherwise specified. If the receiver power supply AC LINE VOLTAGE switch required repositioning (see Paragraph 2.1.1), remove the four screws securing the transmitter chassis to its case and remove the transmitter chassis. Observe the line voltage switch and ensure that it is correctly positioned. Reinstall the transmitter chassis in the case.

2.1.3 Transmitter Power

(1) Set the POWER switch to OFF.

(2) Plug in the J1-to-J2 cable to both the transmitter and receiver.

(3) Connect the power cord to the three-pronged connector in the front panel.

(4) Connect the power cord to the ac mains.

(5) Set the POWER switch to ON.

2.1.4 Receiver Power

(1) Set the POWER switch to OFF.

(2) Ensure that the J1-to-J2 cable is plugged in to both the transmitter and receiver.

(3) Connect the power cord to the three-pronged connector in the back of the case.

(4) Connect the power cord into the ac source.

(5) Set the POWER switch to ON.

(6) Set the STATUS switch to OPERATE. Observe that the graticule lights.

2.2 CALIBRATION

CAUTION

Ensure that J6 and J7 are free of any connections.

(1) On the transmitter, press the CAL button.

(2) On the receiver, press the CAL button.

(3) Observe the position of the spot on the screen; it should be at the intersection of the 0 dB and the 800 Hz lines.

(4) If the spot is at 0 dB and 800 Hz on the screen of the receiver, the set is in calibration; proceed with your measurements. If not, proceed to Step 5.

(5) Turn the slotted-head control marked ↕ to move the spot up or down to the 0 dB line on the screen if necessary.

(6) Turn the slotted-head control marked ↔ to move the spot left or right to the 800 Hz line on the screen if necessary.

(7) When the spot is adjusted to the intersection of the 0 dB and the 800 Hz lines, the set is in calibration; proceed with your measurements.

2.3 BATTERY USE AND CARE

The transmitter and receiver each has its individual battery, battery charger, ac line cord, and controls. The transmitter battery is in the transmitter unit. The receiver battery is in the receiver power supply unit on the rear of the receiver.

The transmitter and receiver each has a CHARGE RATE switch and LOW BATT indicator lamp. The receiver CHARGE RATE switch is on the power supply box front panel.

When operating the Model 420 on the self-contained batteries, switch the STATUS of the receiver to STAND BY between measurements. This will conserve battery power and enable the receiver to operate all day without exhausting the batteries. The transmitter POWER may be switched OFF when a substantial time will elapse between measurements.

The transmitter LOW BATT lamp starts blinking when there are 30 minutes of operation left. The receiver lamp, which operates in the same manner, starts blinking when about 15 minutes of operation remain.

To charge the battery in either unit, turn the POWER switch OFF, connect the ac line cord and set the CHARGE RATE switch to HIGH. A depleted battery will be fully charged in 14 hours. The high charge rate will not harm the battery. The unit may be used while charging, and the POWER switch may be ON or OFF after installing the ac line cord; the battery will charge in either position. If the unit is being used regularly, the CHARGE RATE switch should be left on HIGH. When storing the set for extended periods, set the CHARGE RATE position to LOW. This is a trickle charge, which ensures full charge when the unit is to be used again.

2.4 CIRCUIT UNDER TEST

Ensure that the circuit to be tested is idle and is available for test. Make it busy in accordance with standard practices.

Ensure that the circuit under test is properly terminated for the test to be made.

Consider whether the circuit under test contains echo-suppressors, in-band signalling equipment, or other apparatus which will respond to frequencies in the voice band. If so, take necessary steps to preclude the equipment from interfering with your test.

If the line connected to the transmitter or receiver is to be seized, ensure that the blocking capacitor at the Model 420 terminals is used.

2.4.1 Battery

Battery on the circuit under test will saturate the transformer in the Model 420 if the circuit is connected directly. If the circuit has battery on it (24 or 48 volt central office battery, or telegraph battery, for example), connect it thru the blocking capacitor terminal. Generally, it is preferable to connect the side with battery, the ring side, to the jack with the capacitor: J7 on the transmitter or J12 on the receiver.

2.4.2 Receiver Off Hook

If a receiver-off-hook condition is required, flip the HOLDING COIL switch to IN.

2.4.3 Circuit Termination

The impedance of the circuit under test is quite sensitive to the termination of the far end. If the far end is open (infinite impedance), the constant-current generator produces a high voltage across the terminals, which is indicated as a high impedance. If the far end is short-circuited (zero impedance), the constant-current generator produces a low voltage across the terminals which is indicated as low impedance. This effect is especially noticeable at low end of the frequency scale.

As the terminating impedance is changed from zero to infinite, the valleys in the trace tend to fill up and the peaks tend to flatten out. There is a value of terminating impedance at which the trace is virtually a straight line.

Both ends of a circuit under test must be properly terminated in order to obtain accurate measurements. Generally speaking, private lines, leased lines, toll circuits, trunks in toll offices, and multiplex channels are designed to 600Ω characteristic impedance. These circuits are properly terminated in a standard impedance, or compromise network, consisting of 600Ω resistance in series with a capacitance of 2.14 or 2.16 μF. Subscriber lines, PBX trunks, exchange inter-office trunks, and tandem trunks are usually designed to 900Ω impedance. These circuits are properly terminated in a standard impedance or compromise network of 900Ω resistance in series with 2.15 μF* capacitance. For some measurements, 800 Hz circuit-net-loss measurements, for example, a simple resistor is adequate, and the capacitance may be omitted. Impedance measurements, balance measurements, and return loss measurements are more critical, and frequently require special terminations and balancing networks tailored to the office in which the circuit terminates.

The Model 420 is designed to provide the proper termination, 135Ω, 600Ω, or 900Ω, for the circuit to which it is connected for test. Both the transmitter and receiver are calibrated to transmit or indicate the correct power level in the impedance selected by the TRANSMIT IMPEDANCE and the RECEIVE IMPEDANCE switches, respectively.

2.4.4 Echo Suppressors

The circuit under test may contain equipment that responds to frequencies in the voice band in such a way as to interfere with your tests. Figure 2-2 illustrates a typical arrangement of terminal equipment. The Model 420, in the auto sweep mode, continuously sweeps the voice band, sending consecutively all frequencies between 50 and 5000 Hz (or 150 and 15,000 Hz in the 15 kHz range). This will affect echo suppressors, single frequency signalling equipment, and perhaps other equipment.

If the circuit under test is a toll message circuit longer than about 1500 miles, or a private line longer than about 2000 miles, it will probably contain an echo suppressor. An echo suppressor is a device on a telephone circuit that detects voice frequencies in one direction of transmission and increases the loss in the opposite direction of transmission. The device operates quickly enough at the start of a burst of speech to avoid clipping the first syllable of a word, and it remains operated long enough to attenuate the echo of the last syllable in the burst.

To permit full duplex operation for transmission of data, echo suppressors are arranged to disable themselves on receipt of a spurt of single-frequency tone of 2150 ±150 Hz which lasts more than 750 ms. On receipt of the signal, the echo suppressor will disable itself, and will remain disabled so long as it detects energy in the band between 800 and 2800 Hz. When energy between 800 and 2800 Hz is interrupted for more than 50 ms, the echo suppressor restores itself to normal operation. The required level for both the disabling tone and the energy at frequencies in the holding band is between −16 dBm0 and 0 dBm0.

** The capacitor in the Model 420 is 2.15 μF ±1%, a compromise between the two standards of 2.14 μF and 2.16 μF. This compromise produces an error of less than ±0.1%.*

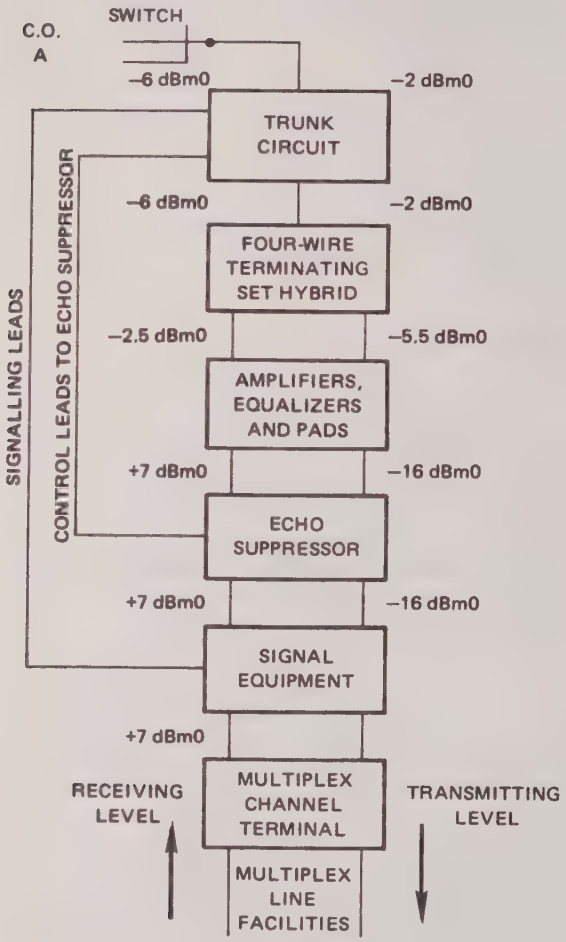


Figure 2-2. Transmission Levels of a Typical Arrangement of Terminal Equipment for a Two-Wire Trunk with 4 dB Loss

The frequency of the Model 420, in auto sweep mode and 5 kHz range, is outside the holding band of 800 to 2800 Hz longer than 50 ms at each end of each sweep. Therefore, in the auto sweep mode, at the fastest sweep rate, the Model 420 will not keep the echo suppressor disabled.

You may prevent the echo suppressor from interfering with the tests in either of two ways:

(1) Manually block the echo suppressor in accordance with standard practices. This will disable it mechanically.

(2) Switch the Model 420 transmitter to manual sweep mode, and control the frequency manually to send the disabling tone and to keep the test signal within the holding band.

2.4.5 Alternating Current Signalling

Alternating current signalling on telephone circuits is usually in-band at 2600 Hz. Circuits arranged for out-of-band signalling separate the voice band, 300 to 3400 Hz, from the signalling frequency, 3700 Hz, in such a manner that the out-of-band signalling features will not interfere with tests and measurements made at the usual access points for voice-frequency testing. In-band signalling equipment, also called "single-frequency signalling," responds to single-frequency tone in the voice band; hence, it may interfere with transmission of the sweep-frequency signal of the Model 420 transmitter.

The frequency of signal tone in the in-band, or single-frequency signalling system is 2600 ±150 Hz in both directions on four-wire circuits, and one way on two-wire circuits; signalling in the other direction on two-wire circuits is at 2400 ±150 Hz. These frequencies are detected and interpreted as signal frequencies as long as there is no detectable energy present at other frequencies in the voice band. The tones are present during idle condition, and absent during the talking condition of the circuit. Sensitivity of the signalling equipment is −29 dBm0 on four-wire circuits, and −32 dBm0 on two-wire circuits. To prevent false operation, a signalling unit has a "guard time delay" of 35 ms during which it may receive power at signalling frequency without functioning.

Model 420 transmitter, in auto sweep mode at maximum sweep speed, crosses the voice band in about one-half second, which is a rate of about 50 Hz per ms. At this rate, the test power is not at signal frequency long enough to operate a properly adjusted single-frequency signalling unit. If the test tone does inadvertently operate the signalling unit, the unit will operate as follows:

(1) Switch in SIGNAL FREQUENCY SUPPRESSION. This switch provides blanking of frequencies between 2450 Hz and 2750 Hz (2600 Hz ±150 Hz).

(2) Disconnect a dialled-up connection.

(3) Transmit ringing current to the distant end of the circuit.

(4) Perform some other supervisory function.

If the tests are extensive, it is recommended that the circuit be turned down, and the signalling equipment blocked in accordance with standard practices to avoid interfering with sweep-frequency tests.

2.5 INSTALLING CRT DISPLAY ACCESSORIES

The CRT display accessory adapter fits into the receiver front panel CRT display cutout as shown in Figure 2-3. The tracing overlay graticule lens accessory clips into the accessory adapter as shown in Figure 2-4.

Figure 2-3. Installing Accessory Adapter

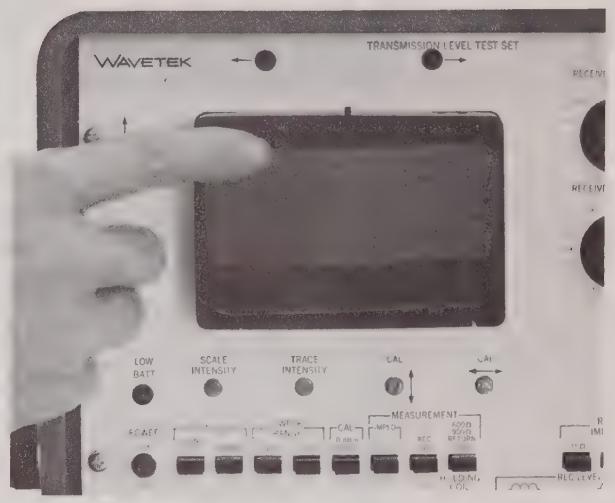


Figure 2-4. Installing Graticule Lens Accessory

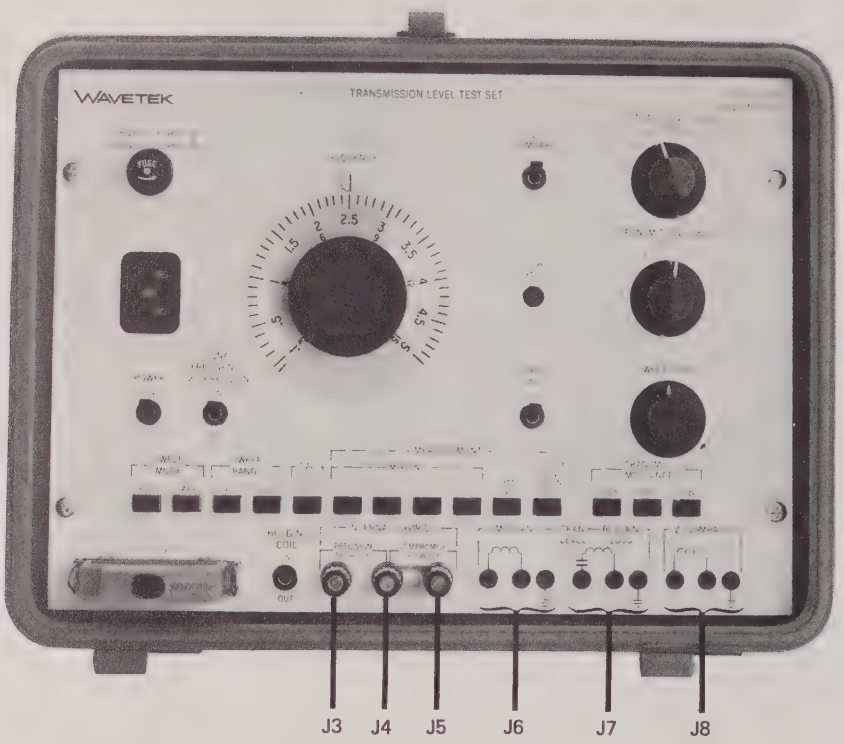
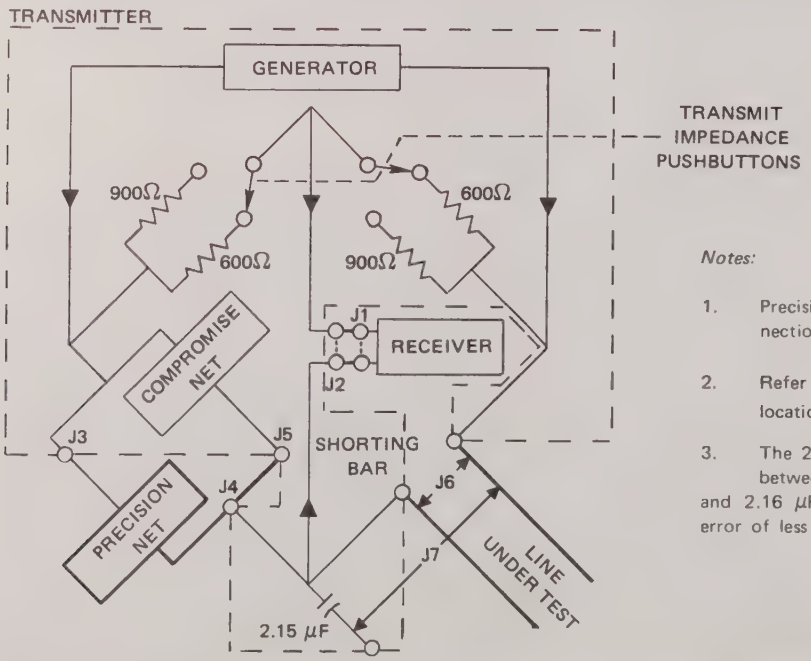


Figure 3-1. Transmitter Front Panel



Notes:

1. Precision net and heavy black line connections are external to the Model 420.
2. Refer to Figure 3-1 for jack number location on the transmitter.
3. The 2.15 μF capacitor is a compromise between the two standards of 2.14 μF and 2.16 μF. This compromise produces an error of less than ±0.1% in expected readings.

Figure 3-2. Internal Hybrid Arrangement for Two-Wire Return Loss Measurement

SECTION 3
OPERATING INSTRUCTIONS

3.1 TRANSMITTER UNIT DESCRIPTION

The principal components of the transmitter (Figure 3-1) are:

(1) Voltage Controlled Sweeping Oscillator

(2) Output Attenuator

(3) 135Ω, 600Ω, and 900Ω Terminating Impedances

(4) Setup Switches

(5) Hybrid with Compromise Network

(6) Jacks for Connecting the Transmitter to the Receiver and Test Apparatus

(7) Power Supply for 115 Vac or 230 Vac, 40 to 400 Hz with Optional Rechargeable Battery

(8) One Milliwatt, 800 Hz Calibration Power

3.1.1 Power and 115 V/230 V Switches and Fuses

The power supply receives ac from 115 V or 230 V mains at 50 to 400 Hz thru the three-pronged connector just to the left of the FREQUENCY dial. A slide switch on the back of the chassis arranges the set for one supply voltage or the other; remove the chassis from the case for access. Use a screwdriver to slide the switch if the indicated voltage is wrong. Fuses for + and − 15 Vdc are also located on the back of the chassis. The front panel FUSE protects the set against excessive current or voltage from the mains.

3.1.2 Charge Rate Switch and Low Battery Indicator

With the power cord connected, the internal battery is being charged by the power supply for either LOW or HIGH charge. The switch is normally left on HIGH and the battery recharges in about 14 hours. The LOW charge rate provides a trickle charge to the battery and is used when the set is stored for extended periods of time. Continuous charge at the HIGH rate will not harm the battery. The LOW BATT lamp flashes when the battery has energy left for about half an hour of operation. The POWER switch connects the transmitter to the dc power supply when ON and disconnects it when OFF. The POWER switch does not disconnect the ac from the internal power supply, so the battery charges even with the POWER switch OFF.

3.1.3 Transmit Impedance Pushbuttons

The TRANSMIT IMPEDANCE switch matches the impedance of the transmitter to a 135Ω, a 600Ω, or a 900Ω circuit. It does this by changing the internal impedance of both the oscillator, and the internal hybrid, and by changing the oscillator voltage. The change in oscillator voltage is necessary to assure that the TRANSMIT LEVEL and the output power are correct for the impedance selected.

3.1.4 Calibration Pushbutton

When pressed, the CAL pushbutton sends 1 milliwatt of power at 800 Hz to the receiver for receiver calibration. This power also appears at the output jack J6 of the transmitter; this jack must be free of any connections during calibration. Operation of any one of the MEASUREMENT pushbuttons releases the CAL pushbutton.

3.1.5 Sweep Mode, Sweep Range, Frequency, and Sweep Speed Controls

The oscillator frequency ranges from 50 to 5000 Hz, or from 150 to 15,000 Hz, depending on the setting of the SWEEP RANGE. With the SWEEP MODE switch set to MAN, the FREQUENCY dial controls the frequency of the oscillator. The outer circle of figures gives the frequency in the 5 kHz range, the inner circle, in the 15 kHz range. With the SWEEP MODE switch set to AUTO, the FREQUENCY dial is disabled, and the oscillator automatically sweeps continuously from the lowest frequency of the range to the highest and returns. The SWEEP SPEED knob controls the sweep rate from about 10 to 30 sweeps per minute.

3.1.6 Impedance Measurement Pushbuttons

The MEASUREMENT switch consists of six pushbuttons, four of which are for IMPEDANCE measuring. When operated, each multiplies the reading of impedance on the receiver screen by the factor shown on the transmitter panel. In the impedance mode, the external connections and controls of the receiver are disabled, and the receiver is connected thru the J1/J2 interconnecting cable to the transmitter. The transmitter applies a constant current to the circuit under test and the receiver cathode ray tube beam is deflected by the voltage across the impedance. When measuring impedance, it is preferable to operate the set at the lowest convenient multipliers.

3.1.7 Transmit Level Measurement Pushbutton

The TRAN LEVEL pushbutton of the MEASUREMENT switch separates the transmitter from the receiver, and arranges the transmitter to send test power into a two-wire line. This mode is used for straightforward measurements of the loss-frequency characteristics of a telephone circuit between two-wire points in the circuit, or in either direction on a four-wire circuit. It is also used to measure return loss at the four-wire side of the hybrid coil, or network in the circuit or apparatus under test.

3.1.8 Return Loss Measurement Pushbutton

The RETURN LOSS pushbutton of the MEASUREMENT switch sets up the Model 420 as a very sensitive impedance bridge which compares the line or apparatus under test with a standard compromise network of either 600Ω or 900Ω depending on the setting of the TRANSMIT IMPEDANCE switch. The impedance bridge is in the form of a hybrid network as illustrated in Figure 3-2. The circuit under test is connected to one side of the hybrid (the equivalent of the line connection of a hybrid coil); the internal compromise network or an external precision network is connected to another side (equivalent to the net connection of a hybrid coil); the receiver is connected across the hybrid to terminals that correspond to the transmitting connection; and the transmitter is connected across the remaining terminals, which correspond to the receiving side. In this arrangement, the RECEIVE LEVEL subtracted algebraically from the TRANSMIT LEVEL gives the return loss.

3.1.9 Transmit Level Switches

The two switches TRANSMIT LEVEL dBm COARSE, and TRANSMIT LEVEL dBm FINE control the output level of the transmitter. The output level in dBm is the algebraic sum of the settings of the two switches. For example, with the COARSE switch set at −10 dBm and the FINE switch set at −3 dBm, the output from the oscillator is −13 dBm.

3.1.10 Holding Coil Switch

This switch allows a telephone line under test to be seized by flipping the HOLDING COIL switch to IN. When using the holding coil, the transmission line must be connected to J7 to block the dc placed on the line.

3.1.11 Z (Impedance) Comparison Switch

Impedance (Z) comparison is done in the AUTO SWEEP MODE only. When the Z COMPARE switch is OFF, there is no Z comparison; when the switch is set on IDENT, the J6 (or J7) output is a modulated, low-to-high frequency sweep, which causes the characteristic impedance curve of the line connected to J6 (or J7) to be a dotted curve on the display. The output of J8 is an unmodulated, high-to-low frequency sweep, which causes the characteristic impedance curve of the line connected to J8 to be a solid curve on the display. Therefore, as the transmitter output sweeps the frequency range up and down, the impedance curves of the two lines connected to the transmitter are displayed on the screen, one as a solid curve and the other as a dotted curve. When the switch is set to ON, both curves are solid.

3.1.12 Internal Hybrid Connectors

INTERNAL HYBRID jacks connect to the network side of the internal hybrid (Figure 3-2). J3 and J4 are the two junctions in the hybrid bridge to which the balancing arm is connected. A compromise network is connected internally between J4 and J5. The shorting link between J4 and J5 connects the compromise network in the balancing arm of the hybrid bridge. The internal hybrid is used for two-wire return loss measurements in which a two-wire circuit is balanced against either the internal compromise network, or an external precision network. This internal hybrid also serves as a sensitive impedance bridge for direct measurement of impedance in terms of resistive, capacitive, and inductive components. Some applications are given in Paragraph 3.4.3.

3.1.13 Impedance, Transmit Level, Return Loss and Z (Impedance) Compare Connectors

TRAN LEVEL – RETURN LOSS are for external connection to the circuit under test. Jack J6 connects directly to the input transformer and the impedance matching network controlled by the TRANSMIT IMPEDANCE pushbuttons. Jack J7 connects to the transformer

thru a capacitor* which will block dc and avoid saturating the transformer, which would affect the measurement. The presence of the capacitor does not affect measurements noticeably at frequencies within the passband of voice-frequency telephone circuits. It should be used when dc is present on the circuit under test. J8 is used to connect the line under test when comparing its impedance characteristics with those of a model line connected to J6 (or J7).

3.1.14 Test Set Cable Connector J2

Jack J2 connects the transmitter to the receiver and contains a power interlock; therefore, the J1/J2 cable or the jumper plug must be plugged into J2 for transmitter operation.

3.1.15 Signal Frequency Suppression Switch

The SIGNAL FREQUENCY SUPPRESSION switch is used to inhibit the transmitter output from 2450 Hz to 2750 Hz (2600 Hz ±150 Hz).

3.2 RECEIVER AND POWER SUPPLY UNITS DESCRIPTION

The principal components of the receiver are:

(1) Cathode Ray Tube

(2) Receive Level Attenuator

(3) Input Jacks

(4) Setup Switches

(5) Power Supply

Figure 3-3 illustrates the receiver power supply front panel, and Figure 3-4 the receiver front panel.

3.2.1 Power and 115 V/230 V Switches and Fuses

The POWER switch connects the dc power supply to the receiver. The power supply unit is attached on the rear of the receiver (Figure 3-3). The power cord, when connected to the three-pronged connector in the back of the power supply box, applies ac power to the power supply at all times, even when the receiver POWER switch is OFF.

The AC LINE VOLTAGE switch located on the front panel of the power supply unit arranges the power supply for either 115 volts or 230 volts, as required, to match the mains voltage. The fuses are on the ac line and the positive and negative dc supply for the receiver.

3.2.2 Charge Rate Switch and Low Battery Indicator

The LOW BATT indicator, located on the receiver front panel, begins to flash when 15 minutes or less of operating time remains in the battery.

* *The capacitor in the Model 420 is 2.15 μF ±1%, a compromise between the two standards of 2.14 μF and 2.16 μF. This compromise produces an error of less than ±0.1%.*

Figure 3-3. Receiver Power Supply

When the ac power cord is connected, the receiver power supply CHARGE RATE switch at HIGH recharges the power supply battery in about 14 hours. The LOW rate is a trickle-charge for use when the set is stored for extended periods. Continuous charge at HIGH will not harm the battery. The receiver POWER switch does not disconnect ac from the power supply, so the battery will charge even with the POWER switch OFF.

3.2.3 Status Pushbuttons

The STATUS pushbuttons conserve battery power between measurements. Only the heater of the cathode ray tube remains on when the STAND BY button is depressed so that there is no warm-up delay when switched from STAND BY to OPERATE. The OPERATE pushbutton applies full power to the receiver components.

3.2.4 CRT Display, Scale, and Trace Intensity Controls and Display Limit Indicators

The tube has a long-persistence phosphor so that the shape of the traced curves can be easily observed. It has two graticules. One graticule has a logarithmic vertical scale graduated in dB; the other has a linear vertical scale graduated in ohms; the horizontal scale is linear and graduated in kilohertz on both graticules. The MEASUREMENT pushbutton automatically selects and lights the proper graticule; the unused graticule is not visible.

The SCALE INTENSITY control is a screwdriver adjustment of the graticule illumination; TRACE INTENSITY controls the brightness of the spot on the screen.

Four off-screen lamps indicate the electron beam location when it is off the screen.

3.2.5 Receive Impedance Pushbuttons

The RECEIVE IMPEDANCE pushbuttons match the set to the impedance of the circuit under test. The 135Ω pushbutton terminates the circuit under test in 135Ω and measures the level across 135Ω. The 600Ω pushbutton terminates the circuit under test in 600Ω and measures the level across 600Ω. The 900Ω pushbutton terminates the circuit under test in 900Ω and measures the level across 900Ω.

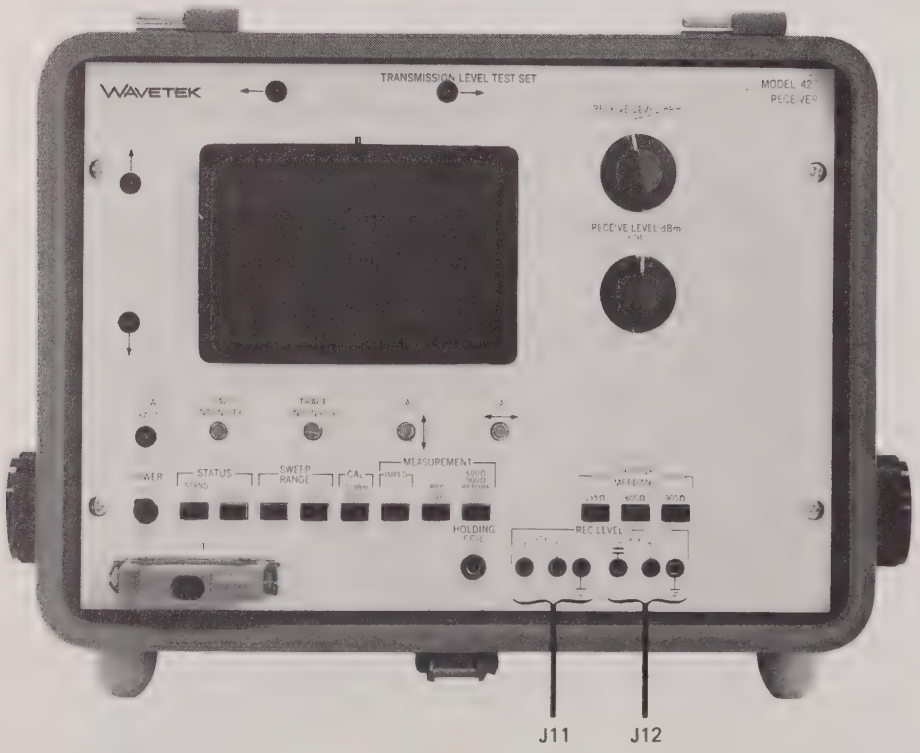


Figure 3-4. Receiver Front Panel

3.2.6 Display Position Controls and Calibration Pushbutton

The two controls marked ↕ and ↔ position the spot at the 0 dB/800 Hz intersection when calibrating the set; these adjustments are made with the CAL pushbuttons depressed on the transmitter and receiver. These two adjustments comprise the entire calibration procedure.

3.2.7 Sweep Range Pushbuttons

The SWEEP RANGE pushbuttons control the range of frequencies over which the receiver functions: 50 to 5000 Hz or 150 to 15,000 Hz. Both the transmitter and the receiver should be set to the same sweep range.

3.2.8 Impedance Measurement Pushbuttons

The MEASUREMENT switch consists of four pushbuttons, one for each mode of measurement. The IMPED pushbutton connects the receiver across the terminals of the transmitter via the J1/J2 cable. The transmitter sends a constant current into the circuit under test so that the voltage across the circuit is a measure of the impedance of the circuit. The value of impedance is the deflection of the spot or trace on the screen of the receiver multiplied by the value of the IMPEDANCE pushbutton operated on the transmitter. For example, if the screen shows 250Ω at 3 kHz, and the transmitter has the Z X 5 pushbutton pressed, the impedance of the circuit under test is 250 X 5 = 1250Ω at 3 kHz.

3.2.9 Received Level Measurement Pushbutton

The REC LEVEL pushbutton arranges the receiver as an electronic voltmeter that is calibrated to read dBm in 135Ω, 600Ω, or 900Ω mode. In this mode, the receiver functions independently of the transmitter. The received level measured on a circuit under test is the algebraic sum of the deflection of the spot and the RECEIVE LEVEL attenuator switches.

3.2.10 Return Loss Measurement Pushbutton

The RETURN LOSS pushbutton connects the receiver as a detector across the internal hybrid (impedance bridge) in the transmitter for two-wire return loss measurements as shown schematically in Figure 3-2. The return loss of the circuit being measured is the algebraic difference of the transmitted level minus the received level. The Model 420 is calibrated to account for the loss in the internal hybrid, so no correction is required for trans-hybrid loss.

3.2.11 Receive Level Selectors

The selectors RECEIVE LEVEL dBm COARSE and RECEIVE LEVEL dBm FINE control the input attenuator for measurements of received level and return loss. The level in dBm of the signal being measured is the algebraic sum of the two attenuator settings and the deflection of the spot on the cathode ray tube.

For example, assume that you want to know the received level at 3000 Hz, and you observe the following:

RECEIVE LEVEL dBm

COARSE	−10 dBm
FINE	+ 4 dBm
Trace on screen at 3 kHz	− 1.5 dBm
Algebraic Sum =	− 7.5 dBm

When the off-screen lamp marked ↑ indicates that the beam is above the top of the screen, turn the RECEIVE LEVEL dBm COARSE switch counterclockwise; i.e., toward the positive dBm values, to bring it into view; and vice versa when the lamp marked ↓ indicates that the beam is off screen on the low side.

3.2.12 Holding Coil Switch

The HOLDING COIL switch allows a telephone line under test to be seized by flipping the switch to IN. When using the holding coil, the transmission line must be connected to J12 to block the dc placed on the line.

3.2.13 Receive Level Connectors

Input to the receiver is thru the REC LEVEL jack, or thru J1 from the transmitter, depending on which MEASUREMENT pushbutton is operated. Jack J11 connects directly to the input transformer and the impedance matching network controlled by the RECEIVE IMPEDANCE pushbuttons. Jack J12 connects to the transformer thru a capacitor* which will block dc and avoid placing an on-hook condition on the circuit under test. The presence of the capacitor does not noticeably affect measurements at frequencies within the passband of voice-frequency telephone circuits. It should be used when dc is present on the circuit under test to avoid saturating the input transformer and upsetting the measurement.

* *The capacitor in the Model 420 is 2.15 μF ±1%, a compromise between the two standards of 2.14 μF and 2.16 μF. This compromise produces an error of less than ±0.1%.*

When the IMPED or the RETURN LOSS button of the MEASUREMENT switch is operated, input to the receiver is via transmitter jacks and the connecting cable J1/J2.

3.2.14 Test Set Cable Connector J1

Jack J1 connects the receiver to the transmitter and contains a power interlock; therefore, the J1/J2 cable or the jumper plug must be plugged into J1 for receiver operation.

3.3 TRANSMISSION LEVEL MEASUREMENTS

The recommended transmitting level for test tone is 13 dB below one milliwatt at the 0 Test Level Point (TLP), which is −13 dBm0 on voice circuits. The 0 TLP is a point of reference in the circuit under test to which transmission losses and levels are referred. It may be theoretical only, and not physically accessible.

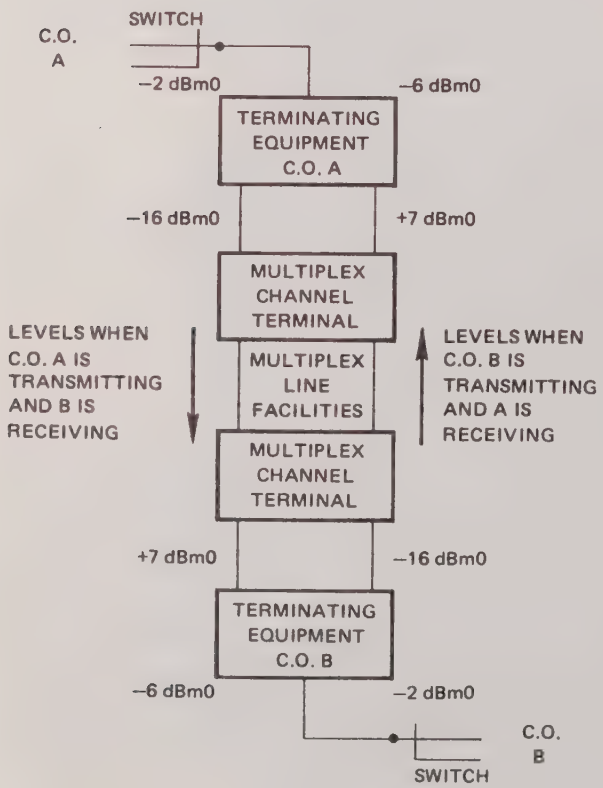


Figure 3-5. Transmission Levels of a Typical Two-Wire Trunk with 4 dB Loss

Historically, when toll circuits were commonly designed to 9 dB loss, when operators did all of the toll switching, and when signalling was ring-down, the common practice was to apply test tone at 1 mW and 800 Hz to the circuit at the toll switchboard at one end, and to measure the received power at the toll switchboard at the other end. The manual toll switchboard, the 9 dB trunk, and ring-down operation have virtually disappeared. The 0 TLP is a vestige of that era. In a machine-switching toll office, the 0 TLP is a figment of the engineers' imagination; the practical access to a trunk is at the outgoing switch, where the design value is −2 dBm0, so this access point becomes a −2 TLP. The designation "−2 dBm0" in Figure 3-5 means the same thing: −2 dB referred to 1 mW at the 0 TLP.

The recommended level of 13 dB below 1 mW at the 0 TLP is currently recommended because:

(1) It approximates the power of the analog signal of an average talker on a voice circuit.

(2) It is the recommended level for tones used in the transmission of digital data on voice circuits.

TLP, Transmission Level Point, is sometimes called Test Level Point. The number preceding it (0, −2, or +7, for example) is the algebraic sum of the gains and losses between the TLP under consideration, and the 0 TLP, or reference point. Figure 3-5 illustrates some typical transmission levels in a two-wire trunk that is designed for an overall circuit net loss of 4 dB.

For example, if 1 mW were to be sent thru a 2 dB pad into the switch of the trunk of Figure 3-5 (the −2 TLP) then at the output of the terminating equipment, you should measure −16 dBm (1 mW down 16 dB). If the test tone were sent at the recommended level, that is, −13 dBm0, then you would read −29 dBm at the −16 TLP.

Similarly, if you are required to send −13 dBm0 into the multiplex channel terminal, which usually is a −16 TLP, the proper transmit level of the Model 420 transmitter would be −29 dBm; and the attendant at the output of the multiplex channel (+7 TLP) should read −6 dBm. Figure 3-6 illustrates similar typical transmission levels on a foreign exchange subscriber line.

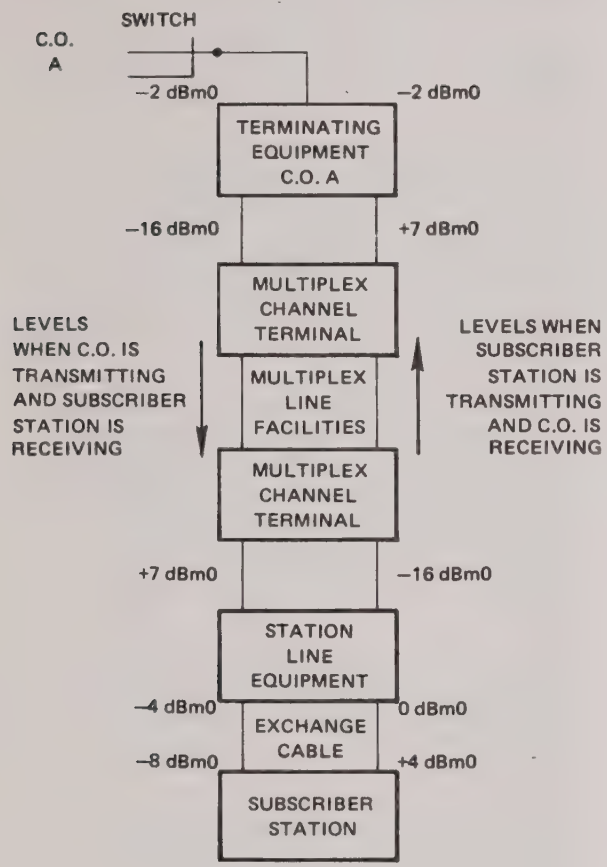


Figure 3-6. Transmission Levels of a Typical Foreign Exchange Station Line with 6 dB Loss Overall, and 4 dB Loss in Subscriber Loop

3.3.1 Transmission Loss and Loss-Frequency Measurements

Requirements for received level or circuit net loss are given as part of the design data for acceptance tests and usually are in the circuit layout records for maintenance purposes. Figures 3-5 and 3-6 illustrate a typical trunk, and a typical long station line. The levels shown in the diagrams are typical of standard practice.

The RECEIVE LEVEL attenuator switches are to be adjusted so that the trace at 800 Hz is 0 dBm on the screen. Then, deviations from 800 Hz for any frequency may be read directly from the screen and compared with the requirements for the circuit under test without regard to circuit loss, reference level, or TLP.

On trunks for data services, typical requirements for deviation from the level at 800 Hz are the following:

(1) Between 350 Hz and 2 kHz, the level should be not more than 1 dB above, nor 3.5 dB below the level at 800 Hz.

(2) Between 2 and 2.5 kHz, the level should be not more than 2.0 dB above, nor 5.0 dB below that at 800 Hz.

3.3.2 Received Level Measurement

Received level is the level in dBm of the signal received. Figure 3-7 is a simplified diagram of the received level. Set up the receiver according to the following table:

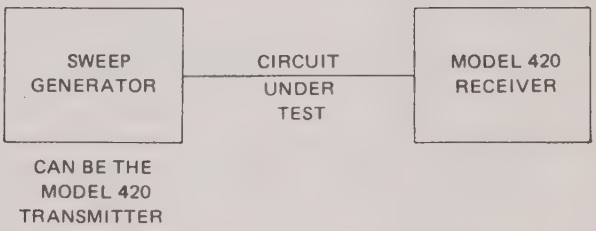


Figure 3-7. Received Level Setup

Control or Connector	Setting or Connection
POWER	ON
RECEIVE IMPEDANCE	See Note 2
SWEEP RANGE	See Note 3
MEASUREMENT	REC LEVEL
STATUS	OPERATE (See Note 4)
Circuit Under Test	J11 (See Note 5)
J1/J2 Cable or Jumper Plug	J1
HOLDING COIL	See Note 5

Notes:

1. The Model 420 transmitter is not required at the receiving end to measure received level or transmission loss. If the Model 420 transmitter is used as the signal source, this measurement is "Transmission Loss". See Paragraph 3.3.3.

2. Press the 135Ω, 600Ω, or 900Ω pushbutton to terminate the circuit under test in its characteristic impedance.

3. Set the SWEEP RANGE to 5 kHz for a voice circuit, or to 15 kHz for a program circuit. The Model 420 receiver will follow the frequency of the received signal.

4. During battery operation, switch STATUS from OPERATE to STAND BY between measurements.

5. If battery of 24 or 48 volts is on the line to be measured or if the line is to be seized, connect the line under test to J12 of the receiver. An internal capacitor blocks dc without affecting the measurement. If a receiver-off-hook condition is required, flip HOLDING COIL switch to IN.

Adjust the RECEIVE LEVEL attenuator so that the spot or trace is at or near 0 dBm. The received level for a particular frequency is the algebraic sum of the setting of the two RECEIVE LEVEL attenuator switches and the position of the spot or trace at that frequency.

In the bridge impedance mode (BRIDG button pressed), the set is calibrated to measure power level in a circuit of 600Ω characteristic impedance; if the circuit under test is a 900Ω circuit, reduce the received level by 1.8 dB. This will correct for the difference in impedances.

The transmission loss, or circuit net loss, between the transmitter at the distant end of the circuit and Model 420 receiver is the algebraic difference between the transmitted level at the sending end, and the received level at the receiving end.

3.3.3 Transmission Loss Measurement

Transmission loss is the difference in level between the transmitted signal and the received signal, expressed in dBm. Figure 3-8 is a simplified diagram of the transmission loss measurement. Set up the test set according to the following table:

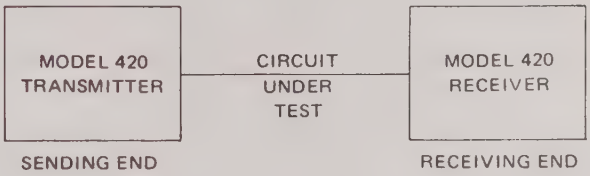


Figure 3-8. Transmission Loss Measurement Setup

Control or Connector	Setting or Connection	
	Transmitter	Receiver
POWER	ON	ON
TRANSMIT and RECEIVE IMPEDANCE	See Note 1	See Note 1
J1/J2 Connecting Cable (See Note 2)	J2	J1
Jumper Plug	See Note 2	See Note 2
SWEEP MODE	AUTO	–
SWEEP RANGE	See Note 3	See Note 3
SWEEP SPEED	As Required	–
MEASUREMENT	TRAN LEVEL	REC LEVEL
STATUS	–	OPERATE (See Note 4)
Circuit Under Test	J6 (See Note 5)	J11 (See Note 5)
TRANSMIT LEVEL	As Required	–
Z COMPARE	OFF	–
HOLDING COIL	See Note 5	See Note 5

Notes:

1. Press the 135Ω, 600Ω, or 900Ω pushbutton to terminate the circuit under test in its characteristic impedance.

2. The connecting cable can be connected, but is not required, between J1 and J2. The transmitter and receiver may be in different buildings at opposite ends of a long circuit. However, **J1 and J2 must have either the cable plug or jumper plug inserted to operate their power interlocks.**

3. Set the SWEEP RANGE on both the transmitter and receiver to 5 kHz when measuring a voice circuit, or to 15 kHz when measuring a program circuit or other circuit with a bandwidth exceeding about 4 kHz. The trace on the receiver follows the frequency of the received signal, and gives the level continuously over the band of frequencies selected.

4. During battery operation, switch the receiver STATUS to STAND BY between measurements. Switch the transmitter POWER OFF when a substantial time will elapse between measurements.

5. If central office battery of 24 or 48 Vdc is on the circuit under test or the line is to be seized, connect the circuit under test to J7 on the transmitter, and J12 on the receiver. An internal capacitor in each set will block dc without affecting the measurements. If a receiver-off-hook condition is required, flip HOLDING COIL switch to IN.

Adjust the RECEIVE LEVEL attenuator so that the spot or trace is at or near 0 dBm. The *received level* is the algebraic sum of the settings of the RECEIVE LEVEL dBm attenuator switches and the position of the spot or trace on the screen of the receiver.

The *transmission loss,* or *circuit net loss,* between the transmitter and the receiver is the algebraic difference between the transmitted level and the received level.

If the bridge impedance mode is used and the receiver is bridged across a 900Ω circuit that is properly terminated, reduce the received level reading by 1.8 dB. (Refer to Paragraph 3.2.5.)

3.4 TRANSMISSION LINE IMPEDANCE MEASUREMENTS

Impedance is the ratio of voltage between the two wires in a circuit to the current in one of them. It is measured by:

(1) Sending a constant current from the transmitter into the line or circuit under test.

(2) Measuring the voltage across the line with the receiver.

The resulting trace of voltage versus frequency is calibrated directly in ohms, giving the magnitude of the measured impedance. The impedance phase angle is not indicated.

3.4.1 Impedance Measurement

Figure 3-9 is a simplified diagram of the impedance measurement. Set up the test set according to the following table (the position of other controls will not affect impedance measurement):

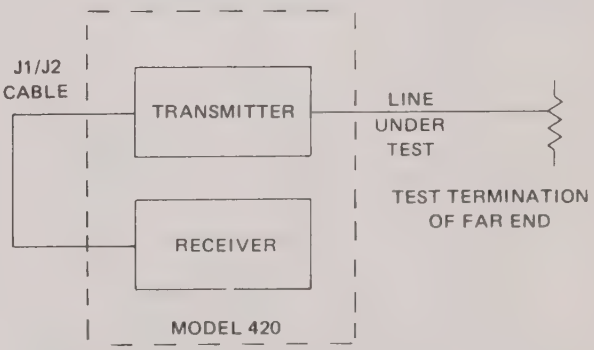


Figure 3-9. Impedance Measurement Setup

Control or Connector	Setting or Connection	
	Transmitter	Receiver
POWER	ON	ON
SWEEP MODE	AUTO	–
SWEEP RANGE	See Note 1	See Note 1
SWEEP SPEED	As Required	–

Control or Connector	Setting or Connection Transmitter	Receiver
STATUS	–	OPERATE (See Note 2)
Circuit Under Test	J6 (See Note 3)	–
J1/J2 Cable	J2	J1
Z COMPARE	OFF	–
HOLDING COIL	See Note 3	–
MEASUREMENT	–	IMPED Z

Notes:

1. Set SWEEP RANGE on the transmitter for 5 kHz for most measurements on voice-grade facilities. Circuits and cable pairs for program and data may require conditioning beyond the usual cutoff frequency of voice-grade circuits; for this purpose, use the 15 kHz range.

2. During battery operation, switch the receiver STATUS to STAND BY between measurements. Switch the transmitter POWER OFF when a substantial time will elapse between measurements.

3. If battery of 24 or 48 volts is on the line to be measured or if the line is to be seized, connect the line under test to J7. An internal capacitor blocks dc without affecting the measurement. If a receiver-off-hook condition is required, flip HOLDING COIL switch to IN.

Adjust the position of the trace or spot on the receiver screen by means of the IMPEDANCE range switches on the transmitter. If the spot or trace is off the screen and the off-screen ↑ lamp lights, switch to a higher range; if the off-screen ↓ lamp lights, switch to a lower range. The measured impedance is the product of the deflection of the spot on the screen of the receiver and the IMPEDANCE range switch on the transmitter.

For example, assume that the trace crosses the 1 kHz frequency mark at a level of 300Ω, and the Z X 5 IMPEDANCE range switch is depressed. The impedance of the circuit under test at 1 kHz is 300 X 5 = 1500Ω.

3.4.2 Impedance Comparison

Impedance comparison is the comparison of the total opposition that each of two circuits offer to the flow of alternating current. The comparison is made by:

(1) Sending a current from the transmitter into each line or circuit under test; transmitting a low-to-high swept frequency signal to one line or circuit and transmitting a high-to-low frequency signal to the other line or circuit.

(2) Measuring the voltage across the lines with the receiver. The characteristic curve of one line or circuit is solid, while the curve of the line receiving the AM signal is dotted.

The resulting traces of voltage versus frequency are calibrated directly in ohms, giving the magnitude of the measured impedance. The impedance phase angle is not indicated.

Figure 3-10 is a simplified diagram of the impedance comparison. Set up the test set according to the following table (the position of other controls will not affect impedance measurement):

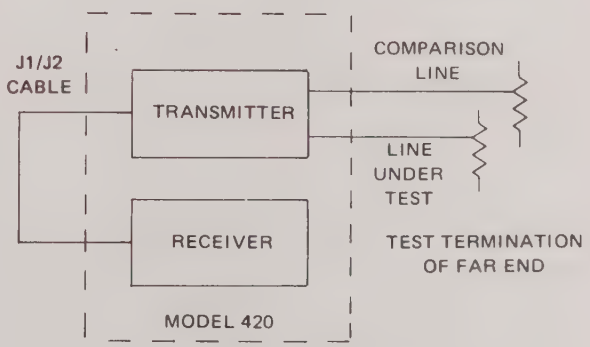


Figure 3-10. Impedance Comparison Setup

Control or Connector	Setting or Connection Transmitter	Receiver
POWER	ON	ON
SWEEP MODE	AUTO	–
SWEEP RANGE	See Note 1	See Note 1
SWEEP SPEED	As Required	–
STATUS	–	OPERATE (See Note 2)
Circuit Under Test	J6 (See Note 3)	–

Control or Connector	Setting or Connection Transmitter	Receiver
Comparison Circuit	J8	–
J1/J2 Cable	J2	J1
Z COMPARE	ON (See Note 4)	–
HOLDING COIL	See Note 3	–
MEASUREMENT	–	IMPED Z

Notes:

1. Set SWEEP RANGE on the transmitter for 5 kHz for most measurements on voice-grade facilities. Circuits and cable pairs for program and data may require conditioning beyond the usual cutoff frequency of voice-grade circuits; for this purpose, use the 15 kHz range.

2. During battery operation, switch the receiver STATUS to STAND BY between measurements. Switch the transmitter POWER OFF when a substantial time will elapse between measurements.

3. If battery of 24 or 48 volts is on the line to be measured or if the line is to be seized, connect the line under test to J7. An internal capacitor blocks dc without affecting the measurement. If a receiver-off-hook condition is required, flip HOLDING COIL switch to IN.

4. The Z COMPARE switch can be set to IDENT (not shown in Figure 3-10) to cause the characteristic curve of the line connected to terminal J6 to be dotted for identification purposes.

Adjust the position of the trace or spot on the receiver screen by means of the IMPEDANCE range switches on the transmitter. If the spot or trace is off the screen and the off-screen ↑ lamp lights, switch to a higher range; if the off-screen ↓ lamp lights, switch to a lower range. The measured impedance is the product of the deflection of the spot on the screen of the receiver and the IMPEDANCE range switch on the transmitter.

For example, assume that the trace crosses the 1 kHz frequency mark at a level of 300Ω, and the Z X 5 IMPEDANCE range switch is depressed. The impedance of the circuit under test at 1 kHz is 300 X 5 = 1500Ω.

3.4.3 Internal Hybrid (Impedance Bridge) Use

In addition to the previous impedance measurements, the internal hybrid circuit may be used in the following manner.

In the RETURN LOSS mode, the Model 420 is a very sensitive measuring bridge. To use it as such, disconnect the shorting link between J4 and J5 and connect a calibrated impedance to J3 and J4. This may be a decade resistor, decade capacitor, variable inductor, or a combination of these. Adjust the calibrated impedance to obtain null. The null is indicated by the lowest received level indicated by the receiver. Slight changes in either direction from balance will cause the trace to indicate an increase in level. The null is most easily obtained with the SWEEP MODE set to MAN and a suitable single frequency selected for the adjustment.

If the length and capacitance per unit length of the cable are known, the measurement of capacitance with Model 420 will give information from which you may detect bridged taps, and deviation from specified capacitance due either to water in the cable, or variation in insulation and spacing during manufacture.

To match an artificial line to a cable pair under test, use the impedance bridge in the Model 420 as follows:

(1) Set up the Model 420 for impedance measurement, connect the cable pair and record the impedance versus frequency trace using the Polaroid camera accessory to the Model 420.

(2) Set up the Model 420 for two-wire return loss (see Paragraph 3.4.2).

(3) Disconnect the shorting link between J4 and J5, and connect the cable pair under test to PRECISION NETWORK terminals J3 and J4; connect the artificial line to measuring terminal J6. (This is to facilitate checking the impedance trace of the artificial line as you approach a balance with the real line.)

(4) Adjust the artificial line to obtain a null in the RETURN LOSS mode.

In theory a perfect balance would produce a null at each individual frequency. In order to check your progress against the recorded impedance curve, press the IMPEDANCE Z switches on both the transmitter and receiver. The trace will be the impedance trace of the artificial line. Without disconnecting either the artificial line or the real line, and without changing your TRANSMIT

and RECEIVE LEVEL switch adjustments, you can compare the previously recorded picture of the impedance of the real line with the trace of the artificial line while you approach a balance with the artificial line.

3.5 RETURN LOSS MEASUREMENTS

Return loss is the dB ratio of the power sent into a two-wire line at a given frequency to the power that "returns" from the line. It is an indirect measure of the difference in impedance between the line and its balancing network. On a working telephone circuit, the return loss gives a measure of how much of a talker's speech power will return to him as echo. The smaller the amount of returned power, the greater is the return loss, and the better is the circuit.

Two-wire return loss is measured by connecting the line under test to the internal hybrid. The sweep generator in the transmitter applies a signal to the transmitting terminals of the internal hybrid; the internal compromise network balances the line under test; the receiver detects and displays a signal in the receiving connection of the internal hybrid as a measure of the difference between the impedances in the line under test and in the compromise network. Figure 3-2 illustrates schematically the internal connections.

Four-wire return loss is a measurement of the proportion of single-frequency power transmitted thru a hybrid into a two-wire line that is returned thru the hybrid to the other side. Figure 3-11 illustrates a typical setup at a PBX, and Figure 3-12 at a toll office. The test is made on the four-wire side of the hybrid that is normally connected in the circuit, and is distinguished from the two-wire return loss, which is made at a point where the circuit is a two-wire circuit and uses the internal hybrid in the Model 420.

For practical purposes, return loss is separated into *echo return loss* and *singing return loss.* Echo return loss is usually measured by sending white noise thru a filter which passes only the band of frequencies between 500 and 2500 Hz. The portion of this power that is returned is measured as a weighted average over the frequency band, using a noise measuring set.

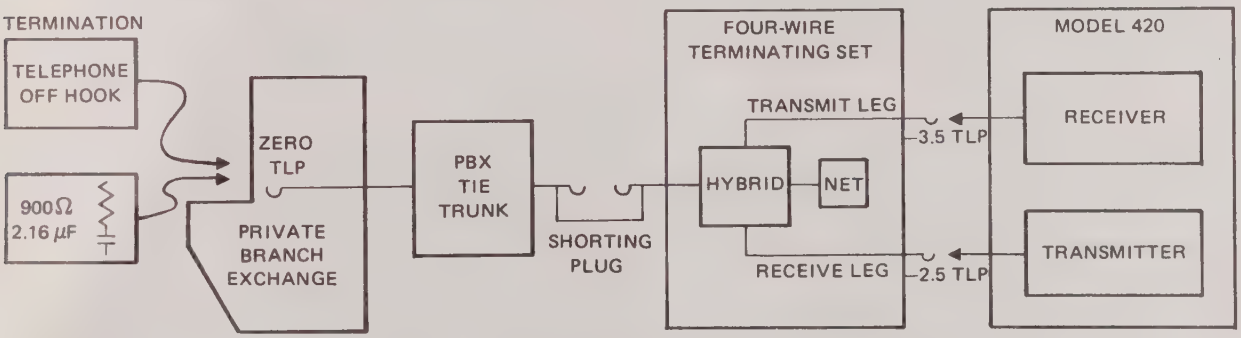


Figure 3-11. Typical Setup for Four-Wire Return Loss Measurement on a 6 dB Tie Trunk

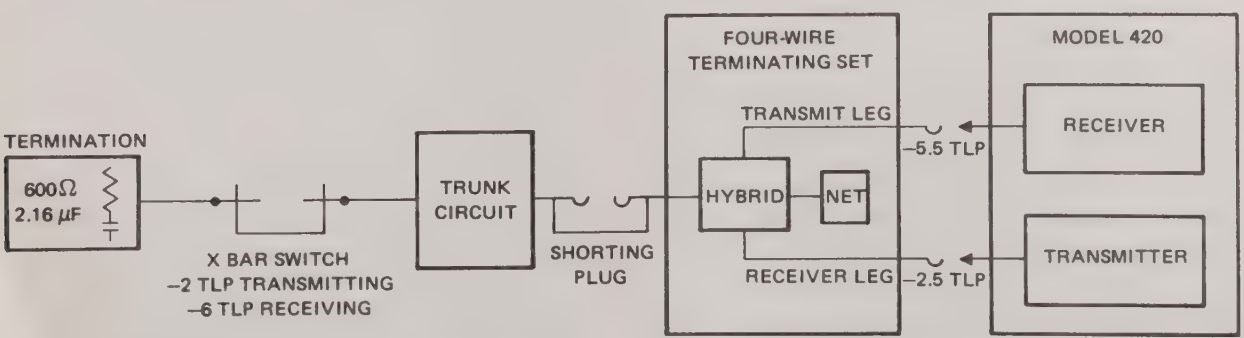


Figure 3-12. Typical Setup for Four-Wire Return Loss Measurement Machine Switching Toll Office on a 4 dB Toll Circuit

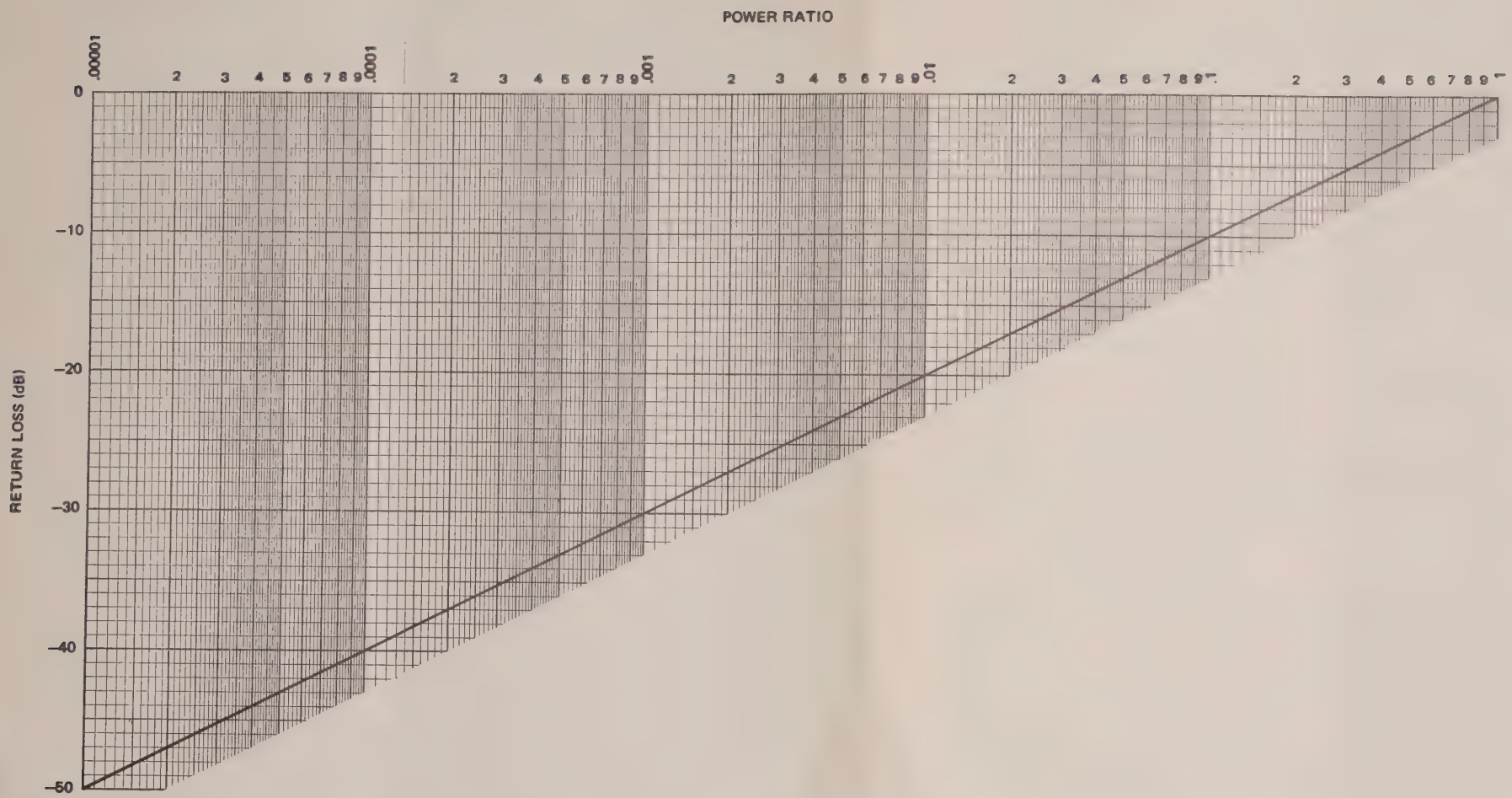


Figure 3-13. Return Loss Versus Power Ratio

CCITT* gives a method of measuring echo return loss, using the trapezoidal rule for numerical integration, that will give a comparable weighted average. In this method, the return losses at the single frequencies 500, 1000, 1500, 2000, and 2500 Hz are measured individually. The dB readings are converted to power ratios (the power ratio = $\log^{-1}$ [dB/10]). Use Figure 3-13 for rapid conversion of values. Fifty percent of the ratio for 500 Hz, and 50% of the ratio for 2500 Hz are added to the sum of the ratios at the other three frequencies; the total is divided by four, giving a weighted average ratio; this ratio is converted back to dB where dB = 10 X Log_{10} Power Ratio. The dB values of the four frequencies for this method can be read on the screen of the Model 420 receiver.

For an example, in a measurement, the five points seen on the trace are as in the first two columns of the table below. Then, from Figure 3-13, the power ratios are as given in the third column, and the weighted ratios in the fourth column.

Measured		Power Ratio	
Frequency	Loss	Measured (See Figure 3-13)	Weighted
500	30 dB	0.0010 X .5	0.0005
1000	25 dB	0.0032	0.0032
1500	28 dB	0.0016	0.0016
2000	35 dB	0.0003	0.0003
2500	23 dB	0.0050 X .5	0.0025
		Total	0.0081
		÷ 4 =	0.0020

Look up power ratio 0.0020 in Figure 3-13 for a Weighted Average Return Loss of 27 dB.

Singing return loss is a measure of stability of the voice circuit that results from the degree to which the two-wire circuit matches the compromise network. It is measured in two separate parts of the voice band: between 200 and 500 Hz, and between 2500 and 3200 Hz. The method used is to introduce gain between the receiving and transmitting connections of the hybrid, thru a filter which passes only the lower or the higher band of frequencies. The gain is increased until sustained oscillation (singing) occurs. The amount of gain is the singing point, and is roughly equivalent to the singing return loss. The lowest value on the return loss versus frequency trace of the Model 420 is a good indication of the probable frequency and value of the singing point. Thus, one setup and one measurement with Model 420 gives all of the values needed for both echo return loss and singing point. The values may be recorded with a camera for later analysis.

Some typical requirements for echo return loss and singing point, as given by various sources, are:

Circuit Measured	Echo Return Loss (dB)		Singing Point (dB)	
	Ave	Min	Ave	Min
Class 5 Switching System Average Overall Subscriber Lines	11	8	6	4
First-Level 2-Wire Office:				
Trunk-to-Trunk	27	25	20	16
Trunk-to-Station Line (Station Off Hook)	15	9	10	6
Main PBX:				
Trunk-to-Station (900Ω at Station)	24	20	18	14
Trunk-to-Station (Station Off Hook)	15	9	8	6

3.5.1 Two-Wire Return Loss Measurement

Two-wire return loss is the dB ratio of the power sent into a two-wire line to the power that returns from the line. It is the measure of the balance between the line and a standard comparison network.

Consider whether the circuit under test contains echo suppressors, in-band signalling equipment, or other apparatus which will respond to voice frequencies. If so, take steps necessary to preclude the equipment from interfering with your test. Figure 3-14 is a simplified diagram of the two-wire return loss measurement. Set up the test set according to the following table:

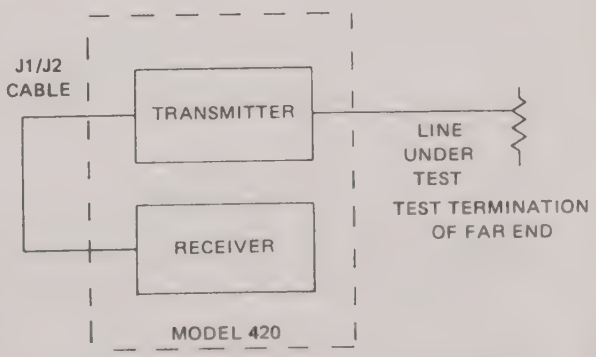


Figure 3-14. Two-Wire Return Loss Measurement Setup

* *The International Telegraph and Telephone Consultative Committee.*

Control or Connector	Setting or Connection Transmitter	Receiver
POWER	ON	ON
TRANSMIT and RECEIVE IMPEDANCE	See Note 1	See Note 1
TRANSMIT LEVEL	0 dBm	–
SWEEP MODE	AUTO	–
SWEEP RANGE	5 kHz	5 kHz
SWEEP SPEED	As Required	–
MEASUREMENT	RETURN LOSS	RETURN LOSS
INTERNAL HYBRID COMPROMISE NETWORK	Short J4 to J5	–
STATUS	–	OPERATE (See Note 2)
Circuit Under Test	J6 (See Note 3)	–
J1/J2 Cable Connected to	J2	J1
Z COMPARE	OFF	–
HOLDING COIL	See Note 3	–

Notes:

1. Press the 600Ω or 900Ω pushbutton to terminate the circuit under test in its characteristic impedance at the measuring end. Also, terminate the circuit under test at the far end.

2. During battery operation, switch the receiver STATUS to STAND BY between measurements. Switch the transmitter POWER OFF when a substantial time will elapse between measurements.

3. If battery of 24 or 48 volts is on the line to be measured or if the line is to be seized, connect the line under test to J7. An internal capacitor blocks dc without affecting the measurement. If a receiver-off-hook condition is required, flip HOLDING COIL switch to IN.

Adjust the RECEIVE LEVEL attenuator so that the spot or trace is at or near 0 dBm. The *received level* is the algebraic sum of the settings of the RECEIVE LEVEL attenuator switches and the position of the spot or trace on the screen of the receiver.

The *measured return loss* is the algebraic difference between the transmitted level of the transmitter, and the received level of the receiver. The Model 420 automatically accounts for the trans-hybrid loss, and reads return loss directly without correction.

3.5.2 Four-Wire Return Loss Measurement

Four-wire return loss is a measurement of the portion of single-frequency power transmitted thru a hybrid into a two-wire line that is returned thru the hybrid to the other side. Figure 3-15 is a simplified diagram of the four-wire return loss measurement. Set up the test set according to the following table:

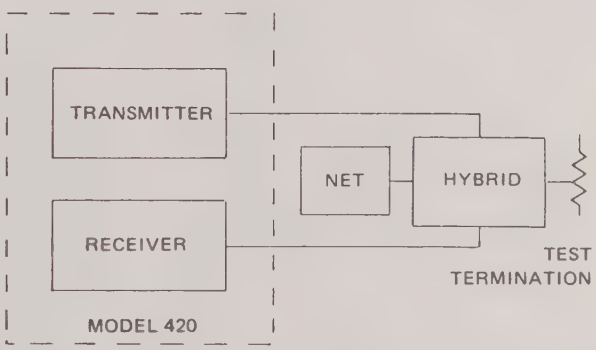


Figure 3-15. Four-Wire Return Loss Measurement Setup

Control or Connector	Setting or Connection Transmitter	Receiver
POWER	ON	ON
TRANSMIT and RECEIVE IMPEDANCE	See Note 1	See Note 1
TRANSMIT LEVEL	See Note 2	–
SWEEP MODE	AUTO	–
SWEEP RANGE	5 kHz (See Note 3)	5 kHz (See Note 3)

Control or Connector	Setting or Connection Transmitter	Receiver
SWEEP SPEED	As Required	–
MEASUREMENT	TRAN LEVEL	REC LEVEL
STATUS	–	OPERATE (See Note 4)
Circuit Under Test	J6 (See Note 5)	J11 (See Note 5)
J1/J2 Cable	J2 (See Note 6)	J1 (See Note 6)
Jumper Plug	See Note 6	See Note 6
Z COMPARE	OFF	–
HOLDING COIL	See Note 5	See Note 5

Notes:

1. Press the 600Ω or 900Ω pushbutton to terminate the circuit under test in its characteristic impedance. Terminate the two-wire side of the circuit under test in a standard termination, or in a test drop in off-hook condition.

2. The four-wire return loss test is usually made at the four-wire side of the four-wire terminating set (4 TS). The transmission levels at this point depend upon the overall circuit net loss, and the TLP. See Paragraph 3.3.

3. The 5 kHz range will enable you to observe frequencies well beyond cut-off point of voice-grade circuits. If you are testing program circuits, or especially conditioned data circuits, you may need to use the 15 kHz range to cover the entire bandwidth.

4. During battery operation, switch the receiver STATUS to STAND BY between measurements. Switch the transmitter POWER OFF when a substantial time will elapse between measurements.

5. If central office battery of 24 or 48 Vdc is on the circuit under test or the line is to be seized, connect the circuit under test to J7 on the transmitter, and J12 on the receiver. An internal capacitor in each set will block dc without affecting the measurements. If a receiver-off-hook condition is required, flip HOLDING COIL switch to IN.

6. The J1/J2 cable connection can be used between the transmitter and receiver, but is not required. The transmitter and receiver may be in different buildings at opposite ends of a long circuit. However, J1 and J2 must have either the cable plug or jumper plug inserted to operate their power interlocks.

Adjust the RECEIVE LEVEL attenuator so that the spot or trace is at or near 0 dBm. The *received level* is the algebraic sum of the settings of the RECEIVE LEVEL attenuator switches and the position of the spot or trace on the screen of the receiver. Observe the *received level* with the circuit under test properly terminated. Then place a short circuit across the two-wire line terminals of the hybrid and observe the *received level* without changing the transmit level. Subtract the first reading (with circuit terminated) from the second (with hybrid shorted). The difference is the *return loss*.

3.6 CABLE LENGTH MEASUREMENT

The length of a pair of wires in a cable is proportional to their capacitance. The capacitance is found by matching the capacitance of the precision network leg of the internal hybrid with the capacitance of the cable pair. If the cable pair capacitance per mile is known, the number of miles of cable is easily calculated. Figure 3-16 is a simplified diagram of the cable length measurement. Set up the test set according to the following table:

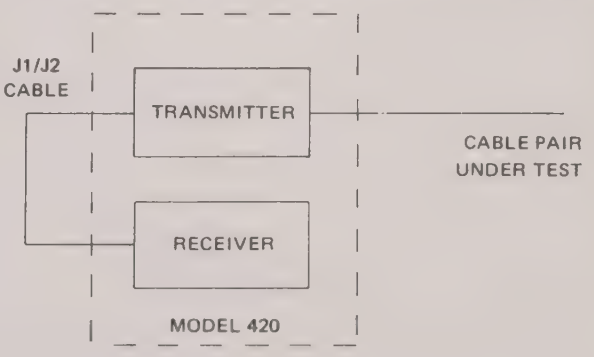


Figure 3-16. Cable Length Measurement Setup

Control or Connector	Setting or Connection Transmitter	Receiver
POWER	ON	ON

Control or Connector	Setting or Connection Transmitter	Receiver
TRANSMIT and RECEIVE IMPEDANCE	900Ω	900Ω
TRANSMIT and RECEIVE LEVEL	0 dBm	–20 dBm
SWEEP MODE	MAN	–
SWEEP RANGE	5 kHz	5 kHz
FREQUENCY	50 Hz (Full Clockwise)	–
MEASUREMENT	RETURN LOSS	RETURN LOSS
INTERNAL HYBRID COMPROMISE NETWORK	Short Removed	–
Pair Under Test	J6 (See Note 2)	–
J1/J2 Cable	J2	J1
STATUS	–	OPERATE (See Note 3)
Z COMPARE	OFF	–
HOLDING COIL	OUT	OUT

Notes:

1. Place a decade capacitor between J3 and J4.

2. Clear the cable pair and leave open at the distant end.

3. During battery operation, switch the receiver STATUS to STAND BY between measurements. Switch the transmitter POWER OFF when a substantial time will elapse between measurements.

Connect the appropriate buildout capacitance for maximum return loss, typically –40 dB. The buildout capacitance will equal the capacitance of the cable. Use Figure 3-17 to determine cable mileage.

The measured capacitance of the cable pair was found to be 0.16 μF. Records show the capacitance for this type of cable to be 0.083 μF/mile. As shown in Figure 3-17, the intersection of the 0.16 μF line and the 0.083 μF/mile line determines the 3800 foot length.

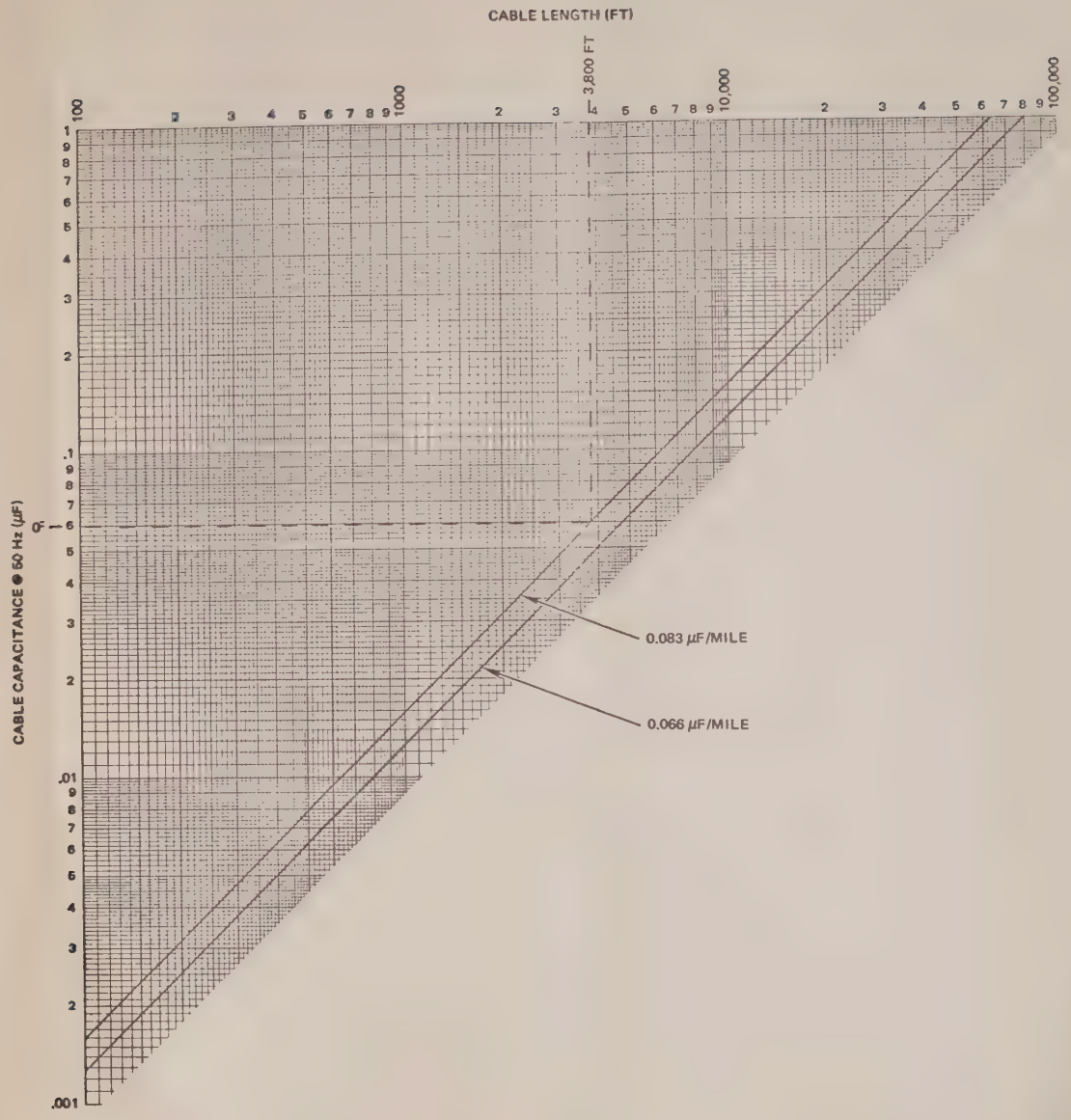


Figure 3-17. Cable Length Chart

available for attenuation in the various operating modes by the BUFFER AMPLIFIER circuit. The CAL mode switch settings present the sine wave directly to the OUTPUT AMPLIFIER circuit as do the IMPEDANCE MEASUREMENT switch settings Z X 1, Z X 2, Z X 5, and Z X 10. The TRAN LEVEL (transmit level) and RETURN LOSS settings route the sine wave through the 1A2 attenuator board FINE TRANSMIT LEVEL selector switch before the output amplifier, attenuating the sine wave in selectable 1 dBm steps down to −10 dBm.

The sine wave from the output amplifier circuit goes to transformer T1 for transformation from a one-line signal to a two-line balanced output. The CAL mode switch settings present the sine wave directly to transformer T1 as do the IMPEDANCE MEASUREMENT switch settings Z X 1, Z X 2, Z X 5, and Z X 10. The TRAN LEVEL and RETURN LOSS settings route the sine wave through the 1A2 attenuator board COARSE TRANSMIT LEVEL selector switch before transformer T1, attenuating the sine wave in selectable 10 dBm steps from +10 dBm down to −40 dBm. Also, the 1A6 signal frequency suppression board grounds the input to the output amplifier between the frequencies 2450 Hz and 2750 Hz (2600 Hz ±150 Hz) when enabled, causing zero volt to be applied to transformer T1 during these frequencies.

The balanced two-line sine wave output from transformer T1 goes to the transmitter front panel output connectors and also through front panel connector J2 and the test set cable to the receiver. See Figure 4-1. The CAL and TRAN LEVEL switch settings route the balanced output directly to the front panel connectors. The IMPEDANCE MEASUREMENT switch settings Z X 1, Z X 2, Z X 5, and Z X 10 insert the necessary resistance into the line for their respective impedance levels.

Setting the RETURN LOSS mode switch converts the transmitter output network into a sensitive hybrid impedance bridge across which the balanced output from transformer T1 is connected (see Figure 4-1). The bridge, or hybrid, compares a transmission line under test with a standard compromise network of either 600Ω or 900Ω in series with a 2.15 μF capacitor, depending on the settings of the TRANSMIT IMPEDANCE pushbuttons (the 135Ω setting cannot be used for a return loss measurement). The circuit or line under test is connected to one side of the hybrid (the equivalent of the line connection of a hybrid coil) and is compared to a known value reference network (equivalent to the net connection of a hybrid coil) on the other side. The reference network can be either the internal compromise network or an external precision network depending on the shorting strap connection between J4 and J5, and the external connection to J3 and J4, respectively. The receiver is connected through the test set cable across the hybrid to sense any level difference between the line under test and the reference network. In this arrangement, the receive level (between J2 pins 3 and 5) is subtracted algebraically from the transmit level (between J2 pins 1 and 3) to derive the amount of return loss.

4.3.2 1A2 Transmitter Attenuator Board Networks

The 1A2 board contains the networks for the fine and coarse transmit level selections. Fold out the 1A2 transmit attenuator board schematic diagram (D420-211). The front panel COARSE and FINE TRANSMIT LEVEL selectors each tap off appropriate levels in voltage divider networks.

4.3.3 1A3 Transmitter Sweep Generator/Impedance Comparison Board Circuits

The 1A3 board contains the circuits for the frequency control voltage sweep, or ramp to the 1A1 transmitter main board input. The 1A3 board also contains the circuit for sweep comparison and the chopping (intensity modulating) circuit for identifying the main output sweep. Fold out the 1A3 transmitter sweep gen/Z compare board schematic diagram (D420-218). As with the 1A1 main board generator circuit, the heart of the sweep generator is a triangle and square wave generator circuit. The triangle wave is developed by a capacitor-charging ramp that is alternately reversed in polarity. The polarity reversal is caused by a flip-flop circuit that in turn produces a square wave. The flip-flop, or HYSTERESIS SWITCH circuit changes state upon detecting amplitude limits of the charging ramps from the SWEEP (TRIANGLE) GENERATOR circuit.

The frequency of the triangle wave sweep ramps is determined by the amount of charging current to C3 in the sweep generator circuit. The amount of charging current determining the frequency, and thus the sweep speed, is determined by the SWEEP SPEED potentiometer in line with the input to the sweep generator circuit. The sweep generator output is combined with an offset voltage from the SWEEP RANGE REFERENCE circuit at the input to the SWEEP OUTPUT BUFFER circuit. This ensures both the 5 kHz and 15 kHz sweep ranges to be in the same display range at the receiver. The sweep output buffer circuit provides the appropriate level of frequency control sweep voltage to the 1A1 main board input.

The COMPARISON CIRCUIT receives the hysteresis switch square wave to alternately energize and deenergize relays K1 and K2. The relays in turn alternately switch the main output OA/OB lines between front panel connectors J6 (or J7) and J8. The characteristic impedance at each output is thus compared to the other.

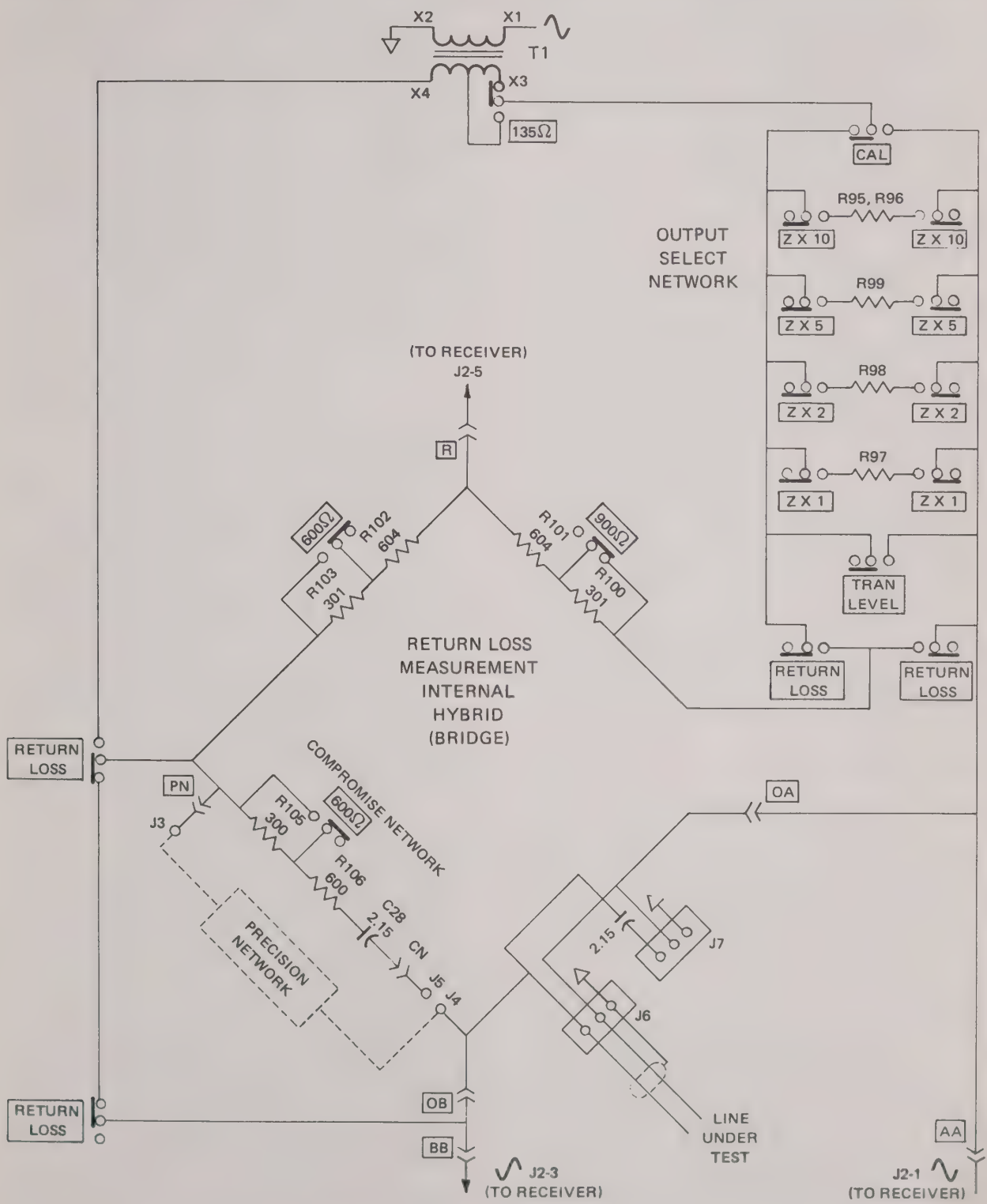


Figure 4-1. Transmitter Output Networks

The INTENSITY MODULATOR FREQUENCY GENERATOR circuit independently produces a square wave output of about 50 times the sweep frequency. When the front panel Z COMPARE switch is set to the IDENTIFY position, the square wave is sent to the receiver. The square wave from the hysteresis switch is also sent to the receiver. The sweep square wave gates the faster square wave which chops or modulates the intensity of the right-to-left trace, causing it to appear dashed.

4.3.4 1A4 Transmitter Battery Charger Board Circuits

The 1A4 board supplies power to the transmitter and contains the ±15 V regulator and battery charging circuits. The 1A4 board also contains the low battery voltage sensing circuit that drives the front panel LOW BATT indicator. Fold out the 1A4 transmitter battery charger board schematic diagram (D420-210). The secondary power from the ac line input transformer supplies the necessary power and voltage reference for battery charging.

The +15 V REGULATOR CIRCUIT monitors the +15 V battery pack voltage. When a voltage lower than the charging reference voltage is sensed, a compensating increase in charging current is turned on. The front panel CHARGE RATE switch determines the reference voltage, and thus the amount of charging current to be turned on.

The LOW BATTERY VOLTAGE SENSING CIRCUIT also monitors the +15 V battery pack voltage. When a voltage lower than +14.4 V is sensed, the flip-flop circuit of Q2 and Q3 begins to alternate, flashing the front panel LOW BATT indicator.

4.3.5 1A5 Battery Assembly

The 1A5 assembly contains two 15 V battery packs, one for supplying +15 volts and the other for supplying −15 volts to the transmitter. Fold out the 1A5 battery assembly drawing (D420-004) in the parts list group of foldouts in Section 7 of this manual. Each battery pack is made up of twelve rechargeable 1.25 V single cell ni-cad (nickel-cadmium) batteries connected in series.

4.3.6 1A6 Signal Frequency Suppression Board Circuits

The 1A6 board contains the circuits for detecting and suppressing the output of frequencies between 2450 Hz and 2750 Hz (2600 Hz ±150 Hz). Fold out the 1A6 signal frequency suppression board schematic diagram (D421-220). The 1A6 board receives the frequency control voltage from the 1A1 board as input. The actual frequencies to be suppressed are "interpreted" from the frequency control voltage. The 1A6 board grounds the input of the 1A1 board output amplifier to suppress the transmitter output.

When the front panel SIGNAL FREQUENCY SUPPRESSION switch is turned on, unity gain amplifier IC1 receives the frequency control voltage which is then halved by voltage divider R6 and R7. Amplifiers IC2 and IC3 are electronic switches that energize and de-energize relay K1 which in turn grounds the 1A1 main board output amplifier. See Figure 4-2. The outputs of IC2 and IC3 are normally at some positive voltage. Because of no difference in potential, K1 is normally deenergized. As the frequency control voltage increases to the voltage corresponding to 2450 Hz, IC2 trips and its output grounds (applies zero volt) to one side of K1 to energize it. As the frequency control voltage increases to the voltage corresponding to 2750 Hz, IC3 trips and its output grounds the other side of K1. Again with no difference in potential, K1 deenergizes.

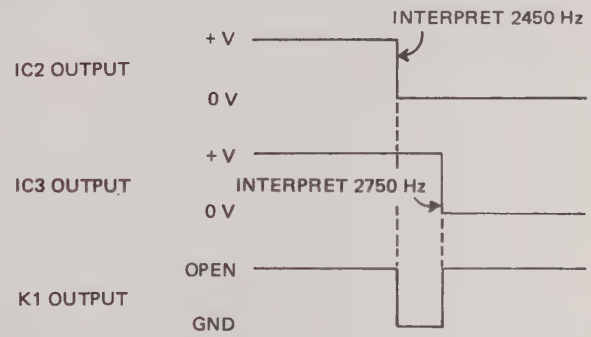


Figure 4-2. Signal Frequency Suppression Logic

4.4 RECEIVER DESCRIPTION

The receiver, unit 2 of the test set, is an oscilloscope that displays either ohms or dB on a vertical scale and Hz on a horizontal scale to compare characteristic impedance or transmission level, respectively, to corresponding signal frequencies. Fold out the unit 2 receiver (and unit 3 receiver power supply) chassis schematic diagram (D398-200, sheet 3 of 3). All signal inputs go to the receiver 2A1 MAIN BOARD. The 2A1 main board produces vertical and horizontal deflection signals for the CRT electron beam and determines from the front panel pushbutton settings which graticule scale (dB versus Hz or ohms versus Hz) is to be used for display. The 2A1 main board also detects the vertical and horizontal beam limits and drives the corresponding front panel indicators.

The 2A2 ATTENUATOR BOARD attenuates the main board signals to their proper display levels, except for calibration reference and impedance measurement where signal level is always within display range. The 2A3 HIGH VOLTAGE/Z COMPARE BOARD receives the

front panel TRACE INTENSITY control voltage and provides the power for producing the electron beam in the CRT. The 2A3 board also receives the impedance comparison control signals from the transmitter. The 2A4 INTERFACE BOARD provides interconnection of the various supply and control voltages between the other boards and circuits in the receiver. The 2A5 CRT DISPLAY ASSEMBLY contains the cathode ray tube (CRT) for producing the display, the deflection yoke for controlling vertical and horizontal beam deflection, the front panel beam position indicators, and the two display scale graticules with their respective lamps. The front panel HOLDING COIL switch connects holding coil 2L2 across input connectors J11 and J12 to maintain the necessary current load on the transmission line for simulating an off-hook condition. Each circuit board aside from the 2A4 interface board and 2A5 CRT assembly is further described in the following paragraphs.

4.4.1 2A1 Receiver Main Board Circuits

The 2A1 board contains the circuits for receiving and controlling the display of signal inputs. Fold out the 2A1 receiver main board schematic diagram (D398-206). Transmission line signals are received through front panel connectors J11 and J12 into the INPUT IMPEDANCE TERMINATIONS network when measuring received levels. When receiving the calibration reference or measuring return loss or impedance, signals are received from the transmitter through the test set cable and front panel connector J1. The balanced two-line input signal is terminated according to the 135Ω, 600Ω, and 900Ω pushbutton settings and applied to transformer T1 for conversion to a one-line signal. The INPUT BUFFER AMPLIFIER circuit conditions the signal to the proper attenuation for display relative to the measurement mode pushbuttons and the attenuation controls in the 2A2 attenuator board.

The conditioned signal is then applied to the vertical deflection control circuits. The signal is also applied to the horizontal deflection control circuits in the received level measurement mode. In the other measurement modes, horizontal deflection is controlled by the synchronizing square wave from the transmitter.

The vertical deflection control circuits are the PEAK DETECTOR (RECTIFIER) circuit, the FREQUENCY-TO-DC CONVERTER (VERTICAL) circuit, and the VERTICAL SWEEP DRIVER circuit. See Figure 4-3. The conditioned input signal is positively rectified by the peak detector or circuit. The rectified pulses are filtered for a dc average, creating a dc level corresponding to the input signal amplitude. This level is then amplified for proper CRT beam deflection by the vertical sweep driver circuit. When the output of the driver is excessively negative or positive for in-range CRT display, front panel limit indicators DS3 and DS4, respectively, turn on to indicate which direction the beam is deflected beyond the display.

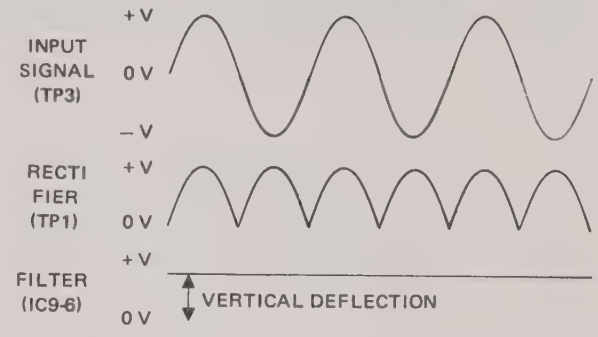


Figure 4-3. Vertical Deflection Control Signals

The horizontal deflection control circuits are the ZERO-CROSSING DETECTOR circuit, the FREQUENCY-TO-DC CONVERTER (HORIZONTAL) circuit, and the HORIZONTAL SWEEP DRIVER circuit. See Figure 4-4. The zero-crossing detector accepts the input signal and puts out a square wave of the same frequency. The square wave is integrated into positive and negative spikes. The negative spikes are dropped out and the positive spikes are shaped into pulses. The pulses are filtered for a dc average, creating a dc level corresponding to the input signal frequency. This level is then amplified for proper CRT beam deflection by the horizontal sweep driver circuit.

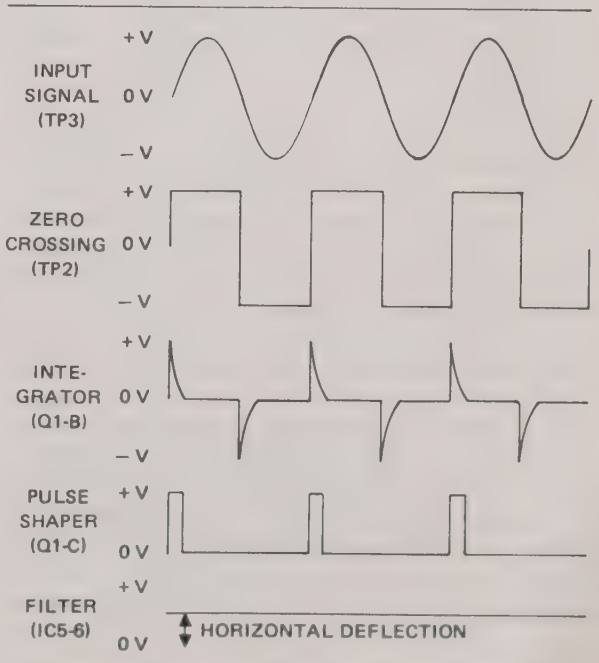


Figure 4-4. Horizontal Deflection Control Signals

When the output of the driver is excessively positive or negative for in-range display, front panel limit indicators DS5 and DS6, respectively, turn on to indicate which direction the beam is deflected beyond the display.

4.4.2 2A2 Receiver Attenuator Board Networks

The 2A2 board contains the networks for the fine and coarse receive level selections. Fold out the 2A2 receive attenuator board schematic diagram (D420-222). The front panel COARSE and FINE RECEIVE LEVEL selectors tap off appropriate levels for signal attenuation through the 2A1 main board in an L-pad attenuator and a voltage divider network, respectively.

4.4.3 2A3 High Voltage/Z Compare Board Circuits

The 2A3 board contains the necessary power circuits for creating the CRT beam. Fold out the 2A3 receiver high voltage/Z compare board schematic diagram (D420-219). The +15 V and −15 V inputs supply CRT filament heater voltage through transistor Q2. The fly-back transformer circuit of T1 creates a resonation of about 20 kHz for developing the necessary high voltages for powering the CRT.

When +12 V is applied to the 2A3 board, capacitor C2 begins to charge and continues until transistor Q1 turns on. Q1 turning on causes a field to expand about the 16-turn primary winding of transformer T1. The expanding field induces current through the 4-turn primary winding, charging C2 negative until Q1 turns off. Q1 turning off causes the field about the 16-turn winding to collapse. The collapsing field induces current through the 4-turn winding to reverse, charging C2 positive again until Q1 turns back on. Q1 turning back on continues the resonation. The resonation frequency is set beyond the audio spectrum to avoid possible interference with test set operation (and possible audible annoyance to the test set operator). The secondary winding of transformer T1 is tapped to provide 3000 volts peak-to-peak and 200 volts peak-to-peak providing the +6000 V CRT plate voltage and +200 V cathode/grid voltages, respectively.

The 3000 V peak-to-peak alternating voltage of the transformer T1 secondary winding is referenced about zero volt (circuit common). This alternating voltage is applied to a voltage quadrupler network to produce the +6000 V CRT plate voltage. Capacitor C5 and diode CR4 clamp the alternating voltage above zero volt, creating a new positive-peak voltage of +3000 volts. The clamped alternating voltage is rectified by diode CR3 and capacitor C7, establishing a +3000 Vdc level. Capacitor C4 and diode CR2 clamp the alternating voltage from the secondary winding above the +3000 V level, creating a new positive peak voltage of +6000 volts. The clamped alternating voltage is rectified by diode CR1 and capacitor C6, establishing the +6000 V CRT plate voltage.

The 200 volts peak-to-peak is rectified and divided for biasing the CRT cathode and grids. The cathode bias, and thus beam intensity, is controlled by the front panel TRACE INTENSITY adjustment. The beam gets brighter as the cathode is biased closer to zero volt, further from the plate potential. Increasing the cathode bias positive, closer to the plate potential, dims the beam.

The Z COMPARE (impedance comparison) circuit controls intermittent trace blanking when the transmitter front panel Z COMPARE switch is set to IDENTIFY. Transistor Q3 is normally turned on, maintaining the zero volt reference from which trace intensity is controlled. When the Z COMPARE switch is set to IDENTIFY, a pulse train alternately turns Q3 on and off. The pulse train out of Q3 alternately raises and lowers the CRT cathode bias, causing the beam to go off and on, respectively. Transistor Q4 enables the beam-blanking pulses only during the right-to-left trace of the beam. During the left-to-right trace, Q4 turns on to maintain the zero volt intensity reference regardless of the state of Q3.

4.5 RECEIVER POWER SUPPLY DESCRIPTION

The receiver power supply, unit 3 of the test set, provides the power necessary for receiver operation. The circuits of the receiver power supply are essentially the same as the power supply circuits in the transmitter except for the additional supply of ±6.4 volts and +12 volts. Fold out the unit 3 receiver power supply (and unit 2 receiver) chassis schematic diagram (D398-200, sheet 3 of 3). The ±15 V supply voltages are interlocked between the receiver and the receiver power supply through the receiver power supply cable and the receiver front panel connector J1. The 3A1 receiver battery charger board circuits are identical to those of the 1A4 transmitter battery charger board with the addition of the ±6.4 VOLT SUPPLY CIRCUITS and the +12 VOLT REGULATOR CIRCUIT. Refer to the description of the 1A4 transmitter battery charger board circuits in Paragraph 4.3.4, but fold out the 3A1 receiver battery charger board schematic diagram (D420-221). The 3A2 battery assembly is identical to the 1A5 battery assembly described in Paragraph 4.3.5.

SECTION 5
PERFORMANCE VERIFICATION AND CALIBRATION

5.1 INTRODUCTION

This section provides the instructions for verifying and calibrating the performance of the Model 420-S-438 test set. Drawings showing the locations of the various calibration adjustments for the test set are located at the back of this section. These drawings may be folded out for reference while referring to the calibration procedures. The verification and calibration instructions are intended for qualified technicians and field engineers.

5.2 FACTORY REPAIR

Wavetek maintains a complete factory repair department for customer instruments. Customers not having the necessary personnel or test equipment may return their instruments to the factory for maintenance. A detailed description of specific problems should be attached to instruments being returned to minimize turnaround time for any calibration or repair.

5.3 PERFORMANCE VERIFICATION

Performance of the test set is correct when the expected result of each calibration adjustment is obtained. There is no need to remove the covers of the test set for any adjustment other than power supply unless the performance is found to be inaccurate or faulty.

5.4 CALIBRATION INSTRUCTIONS

The test set has 16 groups of calibrations involving 31 internal adjustments. These adjustments are initially factory set and sealed in position. The adjustments are located on seven of the ten printed circuit assemblies as shown on the two foldout drawings at the back of this section. The 31 calibration adjustments are listed in Table 5-1 in the sequence in which they should be made.

Table 5-1. MODEL 420-S-438 TEST SET CALIBRATION ADJUSTMENTS

Procedure	Calibration Sequence	Adjustment Sequence
5.6.1	Transmitter Battery Charging Current	(1A4) R4
5.6.2	Transmitter Low Battery Voltage Sensing	(1A4) R10
5.6.3	Receiver Battery Charging Current	(3A1) R4
5.6.4	Receiver Low Battery Voltage Sensing	(3A1) R10
5.7.1	Display Intensity	(2A3) R1
5.7.2	800 Hz, 0 dBm CAL Reference	(1A1) R11, R5
5.7.3	Transmit Level	(1A1) R2, R7, R1, R114
5.7.4	Frequency Dial	(1A1) R13, R10, R14
5.7.5	Sine Distortion	(1A1) R116, R6, R8, R12, R9
5.7.6	Vertical Deflection	(2A1) R4, R89
5.7.7	Horizontal Deflection	(2A1) R2, R3
5.7.8	Sweep Range	(1A3) R2, R3, R1
5.7.9	Peak Detector Symmetry	(2A1) R1
5.7.10	Impedance Measurement	(1A1) R4
5.7.11	Return Loss	(1A1) R3
5.7.12	Signal Frequency Suppression	(1A6) R14, R10

Each calibration adjustment is relatively unaffected by subsequent adjustments in the sequence. The adjustments, however, depend on previous settings in the sequence. Always at least verify the results of preceding adjustments before making a calibration out of sequence. Also verify any subsequent calibrations in the sequence after making an adjustment. If the test set is extremely out of calibration, center all adjustments and perform all calibration procedures in sequence.

5.5 TEST EQUIPMENT

Calibration test equipment is used as a reference for measuring the output of the power supplies and transmitter unit. Receiver performance is visually

monitored by observing the CRT display with the calibrated transmitter as a reference. The following test equipment, or equivalent of other manufacturers, is recommended:

(1) Oscilloscope: Tektronix 454

(2) Distortion Analyzer: Hewlett-Packard 334A

(3) Automatic Counter: Dana 8110

(4) Digital Differential Multimeter: Fluke 8000A

(5) DC Power Supply: Adjustable between +12 V and +20 V

(6) BNC-to-Banana Cable: Hewlett-Packard 11001A (3 each)

(7) BNC "T" Adapter: Hewlett-Packard 1250-0781

(8) 600 Ohm ±1% Resistor

5.6 POWER SUPPLY VERIFICATION AND CALIBRATION PROCEDURE

The test set has two independent power supplies: one is in the receiver power supply unit and the other is in the transmitter unit. Each power supply has its own ac line cord and set of batteries. Calibration adjustments are provided for the correct charging current and low battery voltage sensing. The transmitter and receiver power supplies are to be removed from their cases for verification and adjustment. The receiver power supply cable is also to be unplugged from the back of the receiver.

5.6.1 Transmitter Battery Charging Current

(1) Unplug transmitter ac line cord.

(2) Unplug test set cable or dummy plug from transmitter front panel connector J2.

(3) Unplug red wire from 1A4 battery charger board +BATT pin.

(4) Connect current meter (current function of multimeter) between disconnected red wire and +BATT pin.

(5) Set current meter to measure 200 mA dc.

(6) Plug in transmitter ac line cord.

(7) Set transmitter CHARGE RATE switch to HIGH.

(8) Verify or adjust (1A4) R4 for 100 mA ±2 mA at current meter.

5.6.2 Transmitter Low Battery Voltage Sensing

(1) Unplug transmitter ac line cord.

(2) Unplug test set cable or dummy plug from transmitter front panel connector J2.

(3) Unsolder +BATT side of test jumper on 1A4 battery charger board.

(4) Connect power supply positive lead to test jumper and ground lead to GND pin.

(5) Set power supply for +14.4 V output.

(6) Plug in test set cable or dummy plug to transmitter front panel connector J2.

(7) Plug in transmitter ac line cord.

(8) Turn on transmitter POWER switch.

(9) Verify or adjust (1A4) R10 for LOW BATT indicator (transmitter front panel) flashing at +14.4 V from power supply.

5.6.3 Receiver Battery Charging Current

(1) Unplug receiver power supply ac line cord.

(2) Unplug red wire from 3A1 battery charger board +BATT pin.

(3) Connect current meter between disconnected red wire and +BATT pin.

(4) Set current meter to measure 200 mA dc.

(5) Plug in receiver power supply ac line cord.

(6) Set receiver power supply CHARGE RATE switch to HIGH.

(7) Verify or adjust (3A1) R4 for 100 mA ±2 mA at current meter.

5.6.4 Receiver Low Battery Voltage Sensing

(1) Unplug receiver power supply ac line cord.

(2) Unsolder +BATT side of test jumper on 3A1 battery charger board.

(3) Connect power supply positive lead to test jumper and ground lead to GND pin.

(4) Set power supply for +14.4 V output.

(5) Plug in receiver power supply cable to back of receiver.

(6) Plug in receiver power supply ac line cord.

(7) Turn on receiver POWER switch.

(8) Verify or adjust (3A1) R10 for LOW BATT indicator (receiver front panel) flashing at +14.4 V from power supply.

5.7 PERFORMANCE VERIFICATION AND CALIBRATION PROCEDURE

After completing the power supply verification or calibration and reassembling the test set, set up the test equipment as shown in Figure 5-1. Be sure both the transmitter and receiver units are plugged into an ac power line to avoid excessive drain on the batteries and possible loss of power during performance verification and calibration. Turn on both the transmitter and receiver (POWER switches ON) and set the receiver power supply and transmitter CHARGE RATE switches to HIGH; allow 30 minutes warmup. Begin each group of calibrations with the preliminary front panel settings listed below. After completing

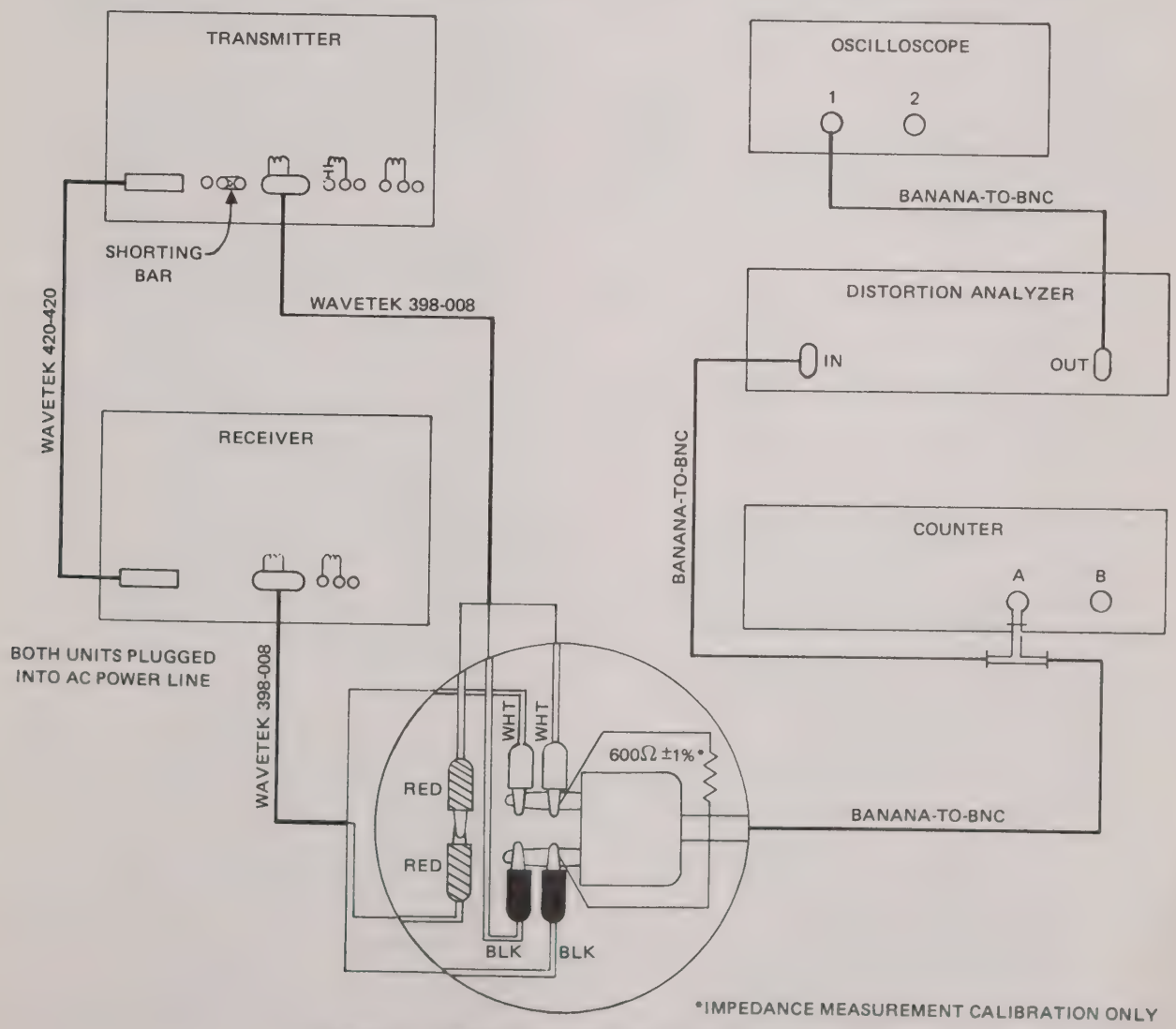


Figure 5-1. General Calibration Setup and Connections

performance verification or calibration, allow a 12 hour battery recharging time on HIGH CHARGE with the test set plugged in and the POWER switches OFF.

Transmitter Unit

SWEEP MODE Pushbuttons	MAN
SWEEP RANGE Pushbuttons	5 kHz
FREQUENCY Dial	800 Hz
SWEEP SPEED Control	As Desired
CAL and MEASUREMENT Pushbuttons	TRAN LEVEL
TRANSMIT IMPEDANCE Pushbuttons	600Ω
TRANSMIT LEVEL Selectors	0 dBm
HOLDING COIL Switch	OUT
Z COMPARE Switch	OFF
SIGNAL FREQUENCY SUPPRESSION Switch	OFF

Receiver Unit

STATUS Pushbuttons	OPERATE
SWEEP RANGE Pushbuttons	5 kHz
CAL and MEASUREMENT Pushbuttons	REC LEVEL
RECEIVE IMPEDANCE Pushbuttons	600Ω
RECEIVE LEVEL Selectors	0 dBm
HOLDING COIL Switch	OUT

5.7.1 Display Intensity

(1) Set transmitter AUTO pushbutton.

(2) Adjust receiver TRACE INTENSITY control fully clockwise.

CAUTION

Avoid excessive brilliance that will damage the phosphor coating of the CRT face. If TRACE INTENSITY fully clockwise causes excessive brilliance, adjust (2A3) R1 fully counterclockwise and then TRACE INTENSITY control fully clockwise.

(3) Verify or adjust (2A3) R1 for maximum desirable brilliance of beam trace.

(4) Adjust receiver TRACE INTENSITY control for normal desirable brilliance of beam trace.

(5) Reset transmitter MAN pushbutton.

5.7.2 800 Hz, 0 dBm CAL Reference

(1) Set transmitter CAL pushbutton.

(2) Verify or adjust (1A1) R11 for 800 Hz ±2 Hz at counter.

(3) Verify or adjust (1A1) R5 for 0.775 Vrms (0 dBm) at distortion analyzer.

(4) Reset transmitter TRAN LEVEL pushbutton.

5.7.3 Transmit Level

(1) Verify or adjust (1A1) R2 for 0.775 Vrms (0 dBm) at distortion analyzer.

(2) Set transmitter TRANSMIT LEVEL FINE selector to −10 dBm.

(3) Verify or adjust (1A1) R7 for 0.245 Vrms at distortion analyzer.

(4) Set transmitter TRANSMIT IMPEDANCE to 900Ω.

(5) Set receiver RECEIVE IMPEDANCE to 900Ω.

(6) Set transmitter TRANSMIT LEVEL selectors to 0 dBm.

(7) Verify or adjust (1A1) R1 for 0.950 Vrms at distortion analyzer.

(8) Set transmitter TRANSMIT IMPEDANCE to 135Ω.

(9) Set receiver RECEIVE IMPEDANCE to 135Ω.

(10) Verify or adjust (1A1) R114 for 0.365 Vrms at distortion analyzer.

5.7.4 Frequency Dial

(1) Set transmitter FREQUENCY dial to 5 kHz.

(2) Verify or adjust (1A1) R13 for 5 kHz ±10 Hz at counter.

(3) Set transmitter FREQUENCY dial to 50 Hz.

(4) Verify or adjust (1A1) R10 for 50 Hz ±2 Hz at counter.

(5) Set transmitter SWEEP RANGE to 15 kHz.

(6) Set transmitter FREQUENCY dial to 15 kHz.

(7) Verify or adjust (1A1) R14 for 15 kHz ±50 Hz.

(8) Remake preliminary front panel settings.

5.7.5 Sine Distortion

(1) Set transmitter FREQUENCY dial to 50 Hz.

(2) Set transmitter Z X 1 pushbutton.

(3) Set receiver Z pushbutton.

(4) Verify or adjust (1A1) R116 to remove "notch" in sine wave at oscilloscope.

(5) Set transmitter TRAN LEVEL pushbutton.

(6) Set receiver REC LEVEL pushbutton.

(7) Set transmitter SWEEP RANGE to 15 kHz.

(8) Set transmitter FREQUENCY dial to 15 kHz.

(9) Verify or adjust (1A1) R6, R8, and R12 for minimum distortion at distortion analyzer.

NOTE

Varying R8 causes shifts in frequency; therefore, vary R8 in small increments to allow analyzer to settle from momentary off-scale readings.

(10) Set transmitter FREQUENCY dial to 150 Hz.

(11) Verify or adjust (1A1) R9 for minimum distortion at distortion analyzer.

(12) Repeat Steps 8 thru 11 for most minimum distortion, less than 1.0%, at distortion analyzer (minimum typically less than 0.5%). Reverify procedure in Paragraph 5.7.2.

(13) Remake preliminary front panel settings.

5.7.6 Vertical Deflection

(1) Set transmitter AUTO pushbutton.

(2) Verify or loosen and rotate deflection yoke about CRT neck for vertical beam trace parallel to vertical scale lines; retighten to fix position.

(3) Set transmitter TRANSMIT LEVEL selectors to −20 dBm.

(4) Adjust receiver front panel ↕ control for beam trace coincident with −20 dB scale line.

(5) Set transmitter TRANSMIT LEVEL selectors to 0 dBm.

(6) Verify or adjust (2A1) R4 for beam trace coincident with 0 dB scale line.

(7) Repeat Steps 3 thru 6 for most accurate beam trace coincidence, the 0 dB trace to be within 0.1 dB of scale line.

(8) Set transmitter TRANSMIT IMPEDANCE to 135Ω.

(9) Set receiver RECEIVE IMPEDANCE to 135Ω.

(10) Verify or adjust (2A1) R89 for beam trace coincident with 0 dB scale line.

(11) Remake preliminary front panel settings.

5.7.7 Horizontal Deflection

(1) Adjust receiver front panel ↔ control for beam spot centered between 667 Hz and 1 kHz scale lines (about 800 Hz).

(2) Set transmitter FREQUENCY dial to 5 kHz.

(3) Verify or adjust (2A1) R2 for beam spot coincident with 5 kHz scale line.

(4) Repeat Steps 1 thru 3 for most accurate beam spot coincidence.

(5) Set transmitter SWEEP RANGE to 15 kHz.

(6) Set receiver SWEEP RANGE to 15 kHz.

(7) Set transmitter FREQUENCY dial to 15 kHz.

(8) Verify or adjust (2A1) R3 for beam spot coincident with 15 kHz scale line.

(9) Remake preliminary front panel settings.

5.7.8 Sweep Range

(1) Set transmitter AUTO pushbutton.

(2) Verify or adjust (1A3) R2 for left end of beam trace coincident with 50 Hz scale line.

(3) Verify or adjust (1A3) R3 for right end of beam trace coincident with 5 kHz scale line.

(4) Repeat Steps 2 and 3 for most accurate beam trace sweep width.

NOTE

Sharp dip at left end of beam trace may occur due to frequencies less than 50 Hz; proper adjustment requires this dip to be no greater than 0.5 dB from 0 dB scale line.

(5) Set transmitter SWEEP RANGE to 15 kHz.

(6) Set receiver SWEEP RANGE to 15 kHz.

(7) Verify or adjust (1A3) R1 for right end of beam trace coincident with 15 kHz scale line.

(8) Remake preliminary front panel settings.

5.7.9 Peak Detector Symmetry

(1) Set transmitter TRANSMIT LEVEL selectors to −31 dBm.

(2) Verify or adjust (2A1) R1 for continuous beam trace just before distortion of the trace.

(3) Remake preliminary front panel settings.

5.7.10 Impedance Measurement

(1) Connect 600Ω ±1% between transmitter output signal lines (see Figure 5-1).

(2) Set transmitter AUTO pushbutton.

(3) Set transmitter Z X 1 pushbutton.

(4) Set receiver Z pushbutton.

(5) Verify or adjust (1A1) R4 for beam trace coincident with 600Ω scale line. If R4 is adjusted, reverify calibration from Procedure 5.7.5 on.

(6) Disconnect 600Ω resistor and remake preliminary front panel settings.

5.7.11 Return Loss

(1) Unplug test cable (WAVETEK 398-008) from transmitter output.

(2) Set transmitter AUTO pushbutton.

(3) Set transmitter RETURN LOSS pushbutton.

(4) Set receiver RETURN LOSS pushbutton.

(5) Verify or adjust (1A1) R3 for beam trace coincident with 0 dB scale line.

(6) Plug test cable back in and remake preliminary front panel settings.

5.7.12 Signal Frequency Suppression

(1) Set transmitter RETURN LOSS pushbutton.

(2) Set receiver RETURN LOSS pushbutton.

(3) Set transmitter FREQUENCY dial for 2450 Hz at counter.

(4) Verify or adjust (1A6) R14 for frequency drop-off at counter.

(5) Set transmitter FREQUENCY dial for 2750 Hz at counter.

(6) Verify or adjust (1A6) R10 for frequency come-back at counter.

(7) Remake preliminary front panel settings.

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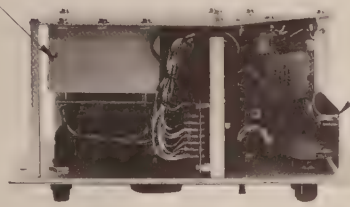
REV	ECN	BY	DATE	APP

BATTERY ASSY
(IA5) C420-004

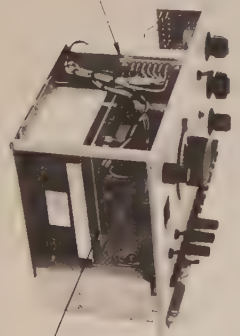
(TOP VIEW)



ATTENUATOR BD
(IA2) D420-011
(NO ADJUSTMENTS)

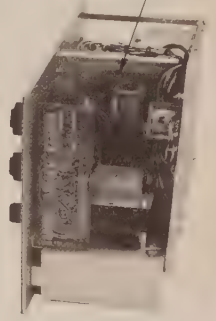
BATTERY CHARGER BD
(IA4) D420-010

SWEEP GENERATOR/
Z COMPARE BD
(IA3) D420-018

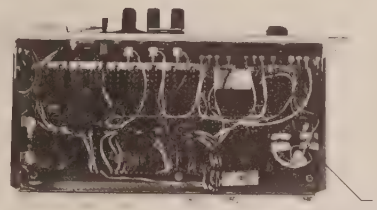


SIGNAL FREQUENCY
SUPPRESSION BD
(IA6) D421-020
(LEFT SIDE VIEW)

UNIT 1
TRANSMITTER
(D398-001)



(RIGHT SIDE VIEW)



MAIN BOARD
(IA1) D398-005

(BOTTOM VIEW)

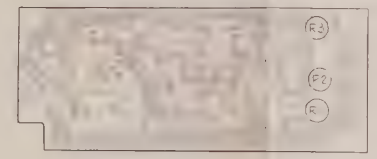
SIGNAL FREQUENCY
SUPPRESSION BD
(IA6) D421-020

BATTERY CHARGER BD
(IA4) D420-010

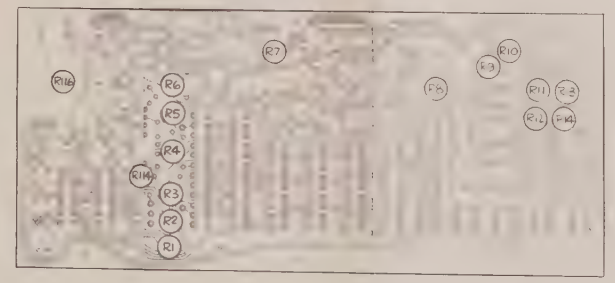
TEST
JUMPER

+ BATT

SWEEP GENERATOR/ Z COMPARE BD
(IA3) D420-018



MAIN BOARD
(IA1) D398-005



NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B. REDMAN	DATE 6/24/74	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL —	PROJ ENGR		TITLE CALIBRATION DWG, UNIT 1
	RELEASE APPROV		
FINISH WAVETEK PROCESS —	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX .010 ANGLES 1 XX .030		
	DO NOT SCALE DWG		MODEL NO 420-S-438 DWG NO D398-503 REV
	SCALE —		CODE IDENT 23338 SHEET 1 OF 2

D398-503

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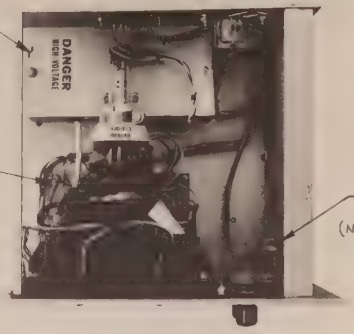
RECEIVER
(TOP VIEW)

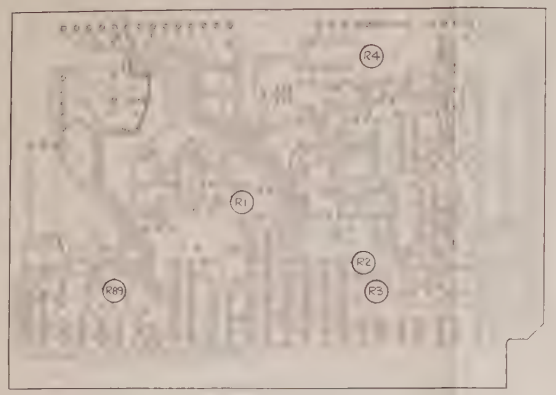
HIGH VOLTAGE BD
(2A3) D420-019
(INSIDE ENCLOSURE)

INTERFACE BD
(2A4) 420-117
(NO ADJUSTMENTS)

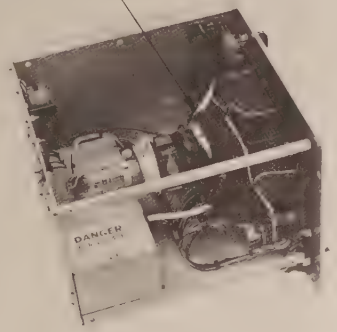
ATTENUATOR BD
(2A2) D420-022
(NO ADJUSTMENTS)



RECEIVER
MAIN BOARD
(2A1) D398-001

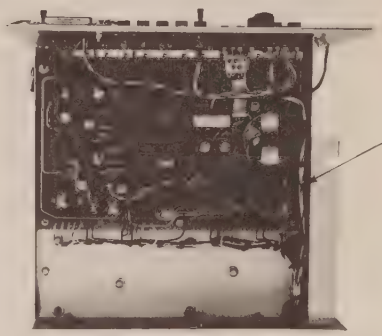


CRT ASSEMBLY
(2A5) D420-042



RECEIVER
(LEFT SIDE VIEW)

UNIT 2
RECEIVER
(D398-002)

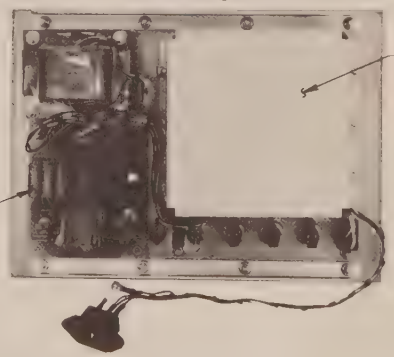


MAIN BOARD
(2A1) D398-006

RECEIVER
(BOTTOM VIEW)

RECEIVER
HIGH VOLTAGE BD
(2A3) D420-019

UNIT 3
RECEIVER POWER SUPPLY
D420-003



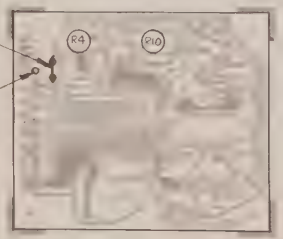
BATTERY ASSY
C420-005
(3A2)

BATTERY CHARGER BD
(3A1) D420-021

POWER SUPPLY
BATTERY CHARGER BD
(3A1) D420-021

TEST
JUMPER

+ BATT



NOTE UNLESS OTHERWISE SPECIFIED

	B. REDMAN	6/24/74	WAVETEK	
		6/25/74	CALIBRATION DWG, UNIT 2 & UNIT 3	
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX .010 ANGLES 1 XX .030			
	DO NOT SCALE DWG		MODEL NO 420-S-438	DWG NO D398-503 REV
	SCALE		CODE IDENT 23338	SHEET 2 OF 2

D398-503

SECTION 6
TROUBLESHOOTING

6.1 INTRODUCTION

This section provides the basic concepts and procedures for troubleshooting the test set. Proper calibration of the test set, if possible, is assumed to have been made before deciding the test set to be faulty. A description of the purpose of each major assembly and a collection of principle waveforms are included. This section supplements the schematic diagrams in Section 7 of this manual. This section is intended for service technicians and engineers acquainted with schematic diagram analysis and operation of the test set.

6.2 TROUBLESHOOTING

Troubleshooting the test set as with any instrument is an orderly process of first identifying the problem, then localizing the source of the problem to a major assembly, and finally isolating the source of the problem.

6.2.1 Identifying the Problem

Identifying a problem with test set operation requires a knowledge of the transmission lines and circuits subject to test and the use of the test set in measuring them. General transmission line considerations to be familiar with before connecting the test set are given in Section 2 of this manual. General considerations of the line under test to be familiar with while using the test set are given in Section 3 of this manual. Instructions for correct test set use are also given in Section 3.

6.2.2 Localizing the Problem

Localizing a problem with test set operation requires an acquaintance with the purpose of each major assembly in the test set. The purpose of each major assembly is presented in Table 6-1. The malfunctioning or failure of any of the listed purposes localizes the trouble to the respective assembly.

Table 6-1. PURPOSE OF MAJOR TEST SET ASSEMBLIES

Assembly		Purpose
1A1	Transmitter Main Board	Sine Wave Synthesis, Mode Determination, Output
1A2	Transmitter Attenuator Board	Transmit Level Mode Attenuation Control
1A3	Sweep Generator/ Z Compare Board	Sweep Generation and Control, Z Compare Blanking Signal
1A4	Transmitter Battery Charging Board	Power Supply, Battery Charging, Low Battery Voltage Sensing for Transmitter
1A5	Battery Pack	DC Power Source for Transmitter
1A6	Signal Frequency Suppression Board	Signal Suppression Between 2450 Hz and 2750 Hz
2A1	Receiver Main Board	Input, Mode Determination, CRT Deflection Control
2A2	Receiver Attenuator Board	Receive Level Mode Attenuation Control
2A3	High Voltage/Z Compare Board	CRT Beam Development, Z Compare Blanking Control
2A4	Interface Board	Internal Interconnection of Supply and Control Voltages
2A5	CRT Display	Signal Display
3A1	Receiver Battery Charger Board	Power Supply, Battery Charging, Low Battery Voltage Sensing for Receiver
3A2	Battery Pack	DC Power Source for Receiver

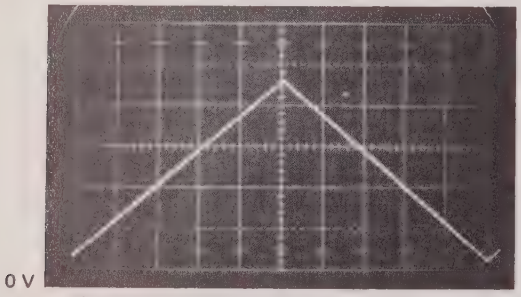
6.2.3 Isolating the Problem

Isolating a problem in the test set requires a knowledge of functional block diagram and signal flow analysis. A description of each assembly and its circuits is provided in Section 4. The schematic diagrams in Section 7 can be used as block diagrams for isolating the problem to a functional block. The following paragraphs supplement the schematic diagrams and discuss principle

waveforms associated with major functional blocks. The waveforms correspond to a 1 kHz, 0 dBm signal set by the transmitter in the transmit and receive level modes with a transmit and receive impedance of 900Ω, unless otherwise specified. The waveforms are keyed in their figure captions with their respective schematic diagram and assembly drawing test points.

6.2.3.1 1A3 Sweep Generator/Z Compare Board Waveforms

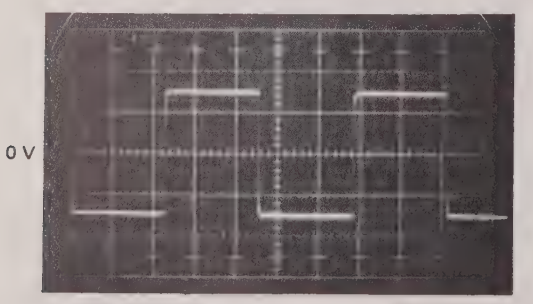
The 1A3 board has two separate generator circuit groups: the sweep generator circuits and the intensity modulator frequency generator (Z compare) circuit. The sweep output circuits are operating normally if with the transmitter front panel SWEEP SPEED control fully clockwise the triangle wave shown in Figure 6-1 is observed at (1A3) TP1.



2 V/CM
0.2 SEC/CM
EXT SYNC ON 1A3-B

Figure 6-1. Sweep Generator Output Waveform at (1A3) TP1

The intensity modulator frequency generator (Z compare) circuit operates independently at about the frequency and amplitude shown in Figure 6-2.

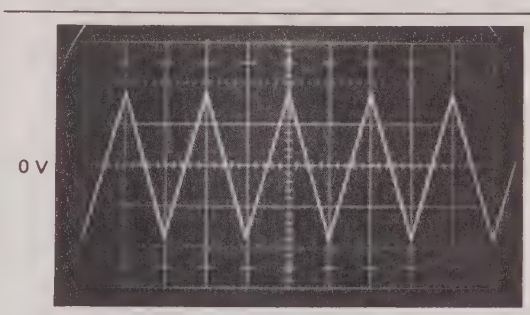


10 V/CM
10 mSEC/CM

Figure 6-2. Z Compare Intensity Modulator Waveform at (1A3) TP2

6.2.3.2 1A1 Transmitter Main Board Waveforms

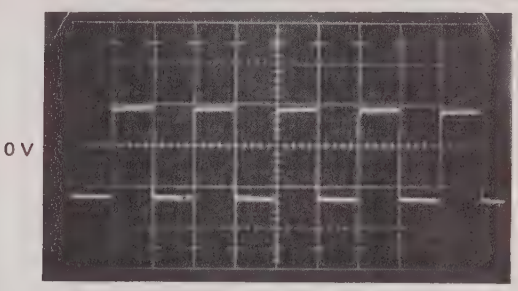
The 1A1 board shapes a sine wave from a triangle wave developed by the triangle wave generator circuit at (1A1) TP2 as shown in Figure 6-3.



1 V/CM
0.5 mSEC/CM

Figure 6-3. Triangle Wave Generator Waveform at (1A1) TP2

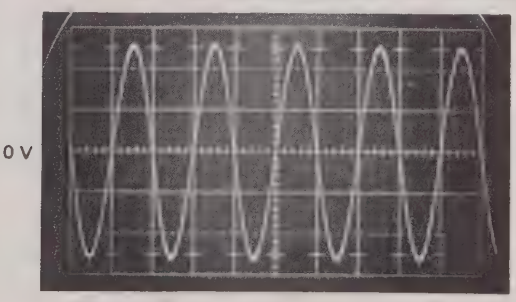
The square wave sync pulse developed by the hysteresis switch circuit at (1A1) TP3 should be as shown in Figure 6-4.



0.2 V/CM
0.5 mSEC/CM

Figure 6-4. Hysteresis Switch (Sync Pulse) Waveform at (1A1) TP3

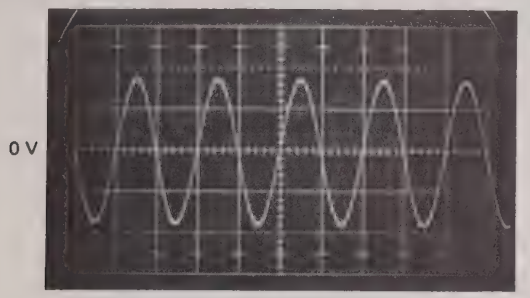
The sine wave is developed by the sine converter circuit at (1A1) TP4 as shown in Figure 6-5.



50 mV/CM
0.5 mSEC/CM

Figure 6-5. Sine Converter Waveform at (1A1) TP4

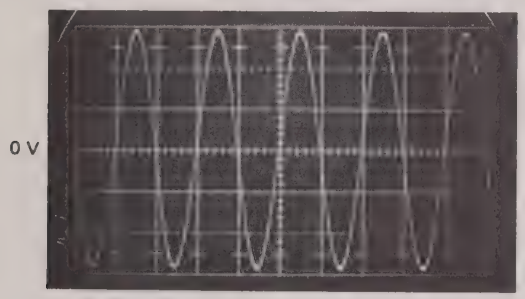
The appropriate level of the sine wave prior to fine attenuation (1 dBm steps) can be seen at (1A1) TP5 as shown in Figure 6-6.



0.5 V/CM
0.5 mSEC/CM

Figure 6-6. Fine Attenuation Input Waveform at (1A1) TP5

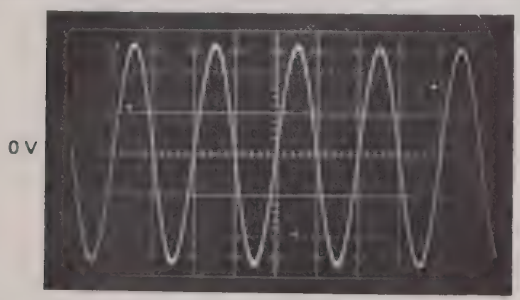
The appropriate level of the sine wave before transformation to a two-line signal and after coarse attenuation (10 dBm steps) can be seen at (1A1) TP6 as shown in Figure 6-7.



0.5 V/CM
0.5 mSEC/CM

Figure 6-7. Coarse Attenuation Output Waveform at (1A1) TP6

6.2.3.3 2A1 Receiver Main Board Waveforms

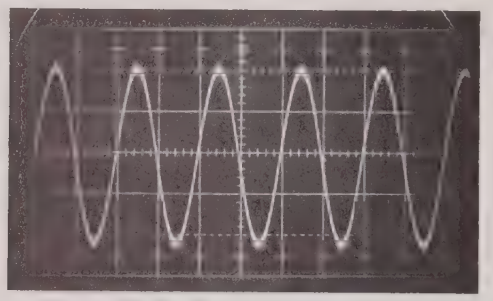


0.5 V/CM
0.5 mSEC/CM

Figure 6-8. Receive Level Attenuation Input Waveform at (2A1) TP5

The 2A1 board receives input signals and conditions them for display with appropriate horizontal and vertical CRT deflection. The appropriate level of the input signal prior to receive level attenuation can be seen at (2A1) TP5 as shown in Figure 6-8.

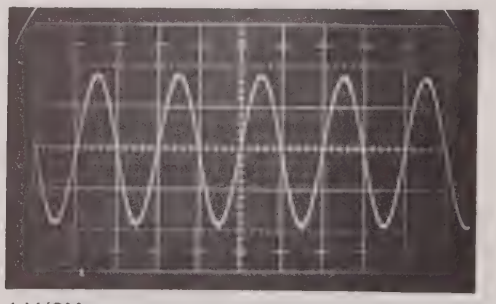
The appropriate level of the signal after receive level attenuation can be seen at (2A1) TP6 as shown in Figure 6-9.



20 mV/CM
0.5 mSEC/CM

Figure 6-9. Receive Level Attenuation Output Waveform at (2A1) TP6

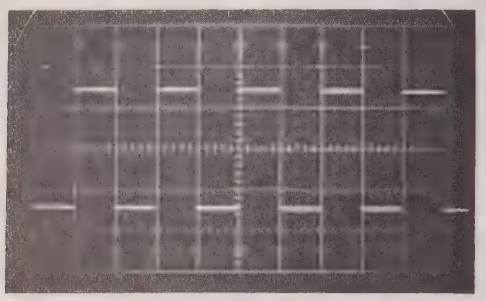
The signal is amplified and conditioned for CRT deflection control as seen at (2A1) TP3 and shown in Figure 6-10.



1 V/CM
0.5 mSEC/CM

Figure 6-10. Horizontal and Vertical Deflection Input Waveform at (2A1) TP3

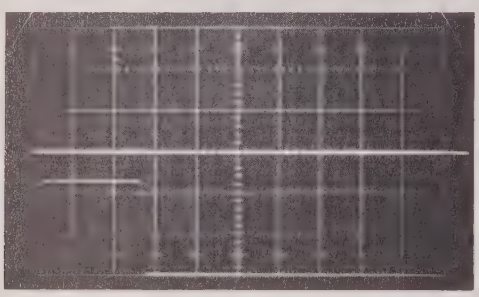
Horizontal deflection is derived by converting frequency to a representative voltage level. The first stage of conversion can be seen at the zero-crossing detector circuit (square wave) output at (2A1) TP2 as shown in Figure 6-11.



10 V/CM
0.5 mSEC/CM

Figure 6-11. Zero-Crossing Detector (Square Wave) Waveform at (2A1) TP2

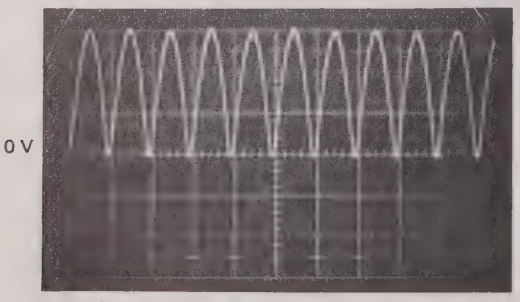
The square waves from the zero-crossing detector are differentiated and the positive edges converted into positive pulses at (2A1) TP7. Figure 6-12 shows these pulses relative to the waveform in Figure 6-11 in the top trace and in expanded detail in the bottom trace.



5 V/CM
Top Trace: 0.5 mSEC/CM
Bottom Trace: 5 μSEC/CM

Figure 6-12. Horizontal Frequency-To-DC Converter Input Waveform at (2A1) TP7

Vertical deflection is derived from converting the positively rectified average dc level of the signal to the appropriate level for the vertical deflection. The positively-rectified signal can be seen at (2A1) TP1 as shown in Figure 6-13.

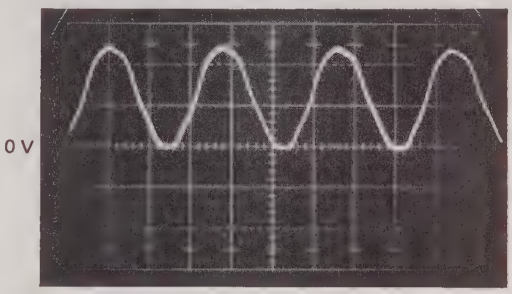


0.5 V/CM
0.5 mSEC/CM

Figure 6-13. Vertical Frequency-To-DC Converter Input Waveform at (2A1) TP1

6.2.3.4 2A3 High Voltage/Z Compare Board Waveforms

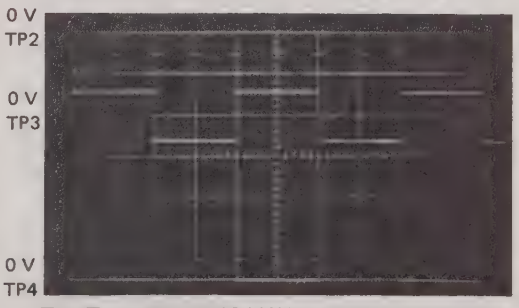
The 2A3 board develops an oscillating voltage from +12 volts and transforms the oscillations into the high voltages necessary for CRT beam development. The primary oscillations prior to high voltage transformation can be seen at (2A3) TP1 as shown in Figure 6-14.



10 V/CM
20 μSEC/CM

Figure 6-14. CRT Beam Oscillation Source Waveform at (2A3) TP1

The 2A3 board also controls the trace blanking for identifying the main transmitter output in the impedance comparison identify mode. The independently running blanking square wave from the transmitter (seen at (2A3) TP2) is gated by the sweep synchronizing square wave from the transmitter (seen at (2A3) TP3) to control the right-to-left sweep modulation or chopping (seen at (2A3) TP4) as shown from top to bottom, respectively, in Figure 6-15.

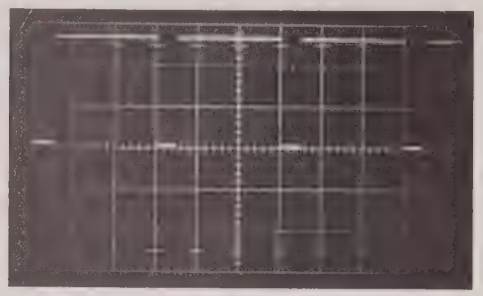


Top Trace: 10 V/CM
Middle Trace: 10 V/CM
Bottom Trace: 20 V/CM

Figure 6-15. Impedance Comparison Identification Control Waveforms at (2A3) TP2, TP3, and TP4

6.2.3.5 1A4 and 3A1 Battery Charger Board Waveform

The 1A4 and 3A1 boards for the transmitter and receiver, respectively, sense when the battery voltage is too low for proper test set operation. When battery voltage is too low, the low battery sensing circuit flashes the front panel LOW BATT indicator with the negative-going pulses seen at (1A4 or 3A1) TP1 as shown in Figure 6-16.



5 V/CM
0.2 SEC/CM

Figure 6-16. Low Battery Indicator Control Waveform at (1A4) or (3A1) TP1

SECTION 7
PARTS LISTS AND SCHEMATIC DIAGRAMS

7.1 INTRODUCTION

This section provides the parts lists, schematic diagrams, and assembly drawings for the test set.

Assembly drawings that do not have schematics are located with the corresponding assembly parts lists. Otherwise, assembly drawings are positioned adjacent to the schematics.

Additional voltage or waveform information, beyond that given in the circuit description, appears on the schematic diagrams at test points and key locations throughout the instrument.

7.2 ADDENDA

Addendum pages are prepared to summarize any changes made after initial manual publication and are inserted immediately inside the rear cover. If no such pages exist, the manual is correct as printed.

7.3 ORDERING PARTS

When ordering spare parts, please specify part number, circuit reference, board, serial number of unit, and if applicable, the function performed.

7.4 DRAWINGS

The following assembly drawings (with corresponding parts lists) and schematics are arranged as follows:

PARTS LIST (AND ASSEMBLY DRAWINGS WITHOUT CORRESPONDING SCHEMATIC DIAGRAMS)

Left-Hand Foldouts | **Right-Hand Foldouts**

TRANSMISSION LEVEL TEST SET

TRANSMISSION LEVEL TEST SET
B398-000 Sheet 2 of 2 (Parts List)

INTERLOCK CONNECTOR (DUMMY PLUG)
B420-421 (Assembly and Parts List)

INTERCONNECT CABLE
B420-420 (Assembly and Parts List)

INPUT CABLE
B398-008 (Assembly and Parts List)

UNIT 1 TRANSMITTER

UNIT 1 TRANSMITTER
B398-001 Sheet 2 of 2 (Parts List)

1A1 TRANSMITTER MAIN BOARD
B398-005 Sheet 3 of 3 (Parts List)

1A3 IMPEDANCE COMPARISON SWEEP BOARD
B420-018 Sheet 2 of 2 (Parts List)

1A5 AND 3A2 BATTERY PACK
C420-004/C420-005 (Assembly and Parts List)

1A1 TRANSMITTER MAIN BOARD
B398-005 Sheet 2 of 3 (Parts List)

1A2 TRANSMITTER ATTENUATOR BOARD
B420-011 Sheet 2 of 2 (Parts List)

1A4 TRANSMITTER BATTERY CHARGER BOARD
B420-010 Sheet 2 of 2 (Parts List)

1A6 SIGNAL FREQUENCY SUPPRESSION BOARD
B421-020 Sheet 2 of 2 (Parts List)

PARTS LIST (AND ASSEMBLY DRAWINGS WITHOUT CORRESPONDING SCHEMATIC DIAGRAMS) (Continued)

Left-Hand Foldouts | **Right-Hand Foldouts**

UNIT 2 RECEIVER

UNIT 2 RECEIVER
B398-002 Sheet 2 of 2 (Parts List)

2A1 RECEIVER MAIN BOARD
B398-006 Sheet 3 of 3 (Parts List)

2A3 HIGH VOLTAGE BOARD
D420-019 Sheet 2 of 2 (Parts List)

2A1 RECEIVER MAIN BOARD
B398-006 Sheet 2 of 3 (Parts List)

2A2 RECEIVER ATTENUATOR BOARD
B420-022 Sheet 2 of 2 (Parts List)

2A5 CRT DISPLAY ASSEMBLY
D420-042 (Assembly and Parts List)

UNIT 3 RECEIVER POWER SUPPLY

UNIT 3 RECEIVER POWER SUPPLY
D420-003 Sheet 1 of 2 (Assembly)

3A1 RECEIVER BATTERY CHARGER BOARD
B420-021 Sheet 2 of 2 (Parts List)

UNIT 3 RECEIVER POWER SUPPLY
B420-003 Sheet 2 of 2 (Parts List)

SCHEMATIC DIAGRAMS (AND CORRESPONDING ASSEMBLY DRAWINGS)

Left-Hand Foldouts	Right-Hand Foldouts

TRANSMISSION LEVEL TEST SET

TRANSMISSION LEVEL TEST SET D398-000 Sheet 1 of 2 (Assembly)	TRANSMISSION LEVEL TEST SET D398-200 Sheet 1 of 3 (Interconnect)

UNIT 1 TRANSMITTER

UNIT 1 TRANSMITTER D398-001 Sheet 1 of 2 (Assembly)	TRANSMISSION LEVEL TEST SET D398-200 Sheet 2 of 3 (Unit 1 Schematic)
1A1 TRANSMITTER MAIN BOARD D398-005 Sheet 1 of 3 (Assembly)	1A1 TRANSMITTER MAIN BOARD D398-205 (Schematic)
1A2 TRANSMITTER ATTENUATOR BOARD D420-011 Sheet 1 of 2 (Assembly)	1A2 TRANSMITTER ATTENUATOR BOARD D420-211 (Schematic)
1A3 IMPEDANCE COMPARISON SWEEP BOARD D420-018 Sheet 1 of 2 (Assembly)	1A3 IMPEDANCE COMPARISON SWEEP BOARD D420-218 (Schematic)
1A4 TRANSMITTER BATTERY CHARGER BOARD D420-010 Sheet 1 of 2 (Assembly)	1A4 TRANSMITTER BATTERY CHARGER BOARD D420-210 (Schematic)
1A6 SIGNAL FREQUENCY SUPPRESSION BOARD D421-020 Sheet 1 of 2 (Assembly)	1A6 SIGNAL FREQUENCY SUPPRESSION BOARD B421-220 (Schematic)

UNIT 2 RECEIVER

UNIT 2 RECEIVER D398-002 Sheet 1 of 2 (Assembly)	TRANSMISSION LEVEL TEST SET D398-200 Sheet 3 of 3 (Units 2 and 3 Schematic)
2A1 RECEIVER MAIN BOARD D398-006 Sheet 1 of 3 (Assembly)	2A1 RECEIVER MAIN BOARD D398-206 (Schematic)
2A2 RECEIVER ATTENUATOR BOARD D420-022 Sheet 1 of 2 (Assembly)	2A2 RECEIVER ATTENUATOR BOARD D420-222 (Schematic)
2A3 HIGH VOLTAGE BOARD D420-019 Sheet 1 of 2 (Assembly)	2A3 HIGH VOLTAGE BOARD D420-219 (Schematic)

UNIT 3 RECEIVER POWER SUPPLY

3A1 RECEIVER BATTERY CHARGER BOARD D420-021 Sheet 1 of 2 (Assembly)	3A1 RECEIVER BATTERY CHARGER BOARD D420-221 (Schematic)

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REV	ECN	BY	DATE	APP

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
1	INSTRUMENT CASE	WAVETEK	23338	B420-500	1
2	TRANSMITTER	WAVETEK	23338	B398-001	1
3	RECEIVER	WAVETEK	23338	B398-002	1
4	POWER SUPPLY	WAVETEK	23338	B420-003	1
5	PIVOT BASE	WAVETEK	23338	B420-309	2
6	HAIR	WAVETEK	23338	B420-315	1
	RETAINER	WAVETEK	23338	B420-308	1
8	BEZEL	WAVETEK	23338	B420-038	1
9	TUBE TRACE	WAVETEK	23338	B420-361	10
10	CABLE, INTERCONNECT	WAVETEK	23338	B420-420	1
11	INTERLOCK CONN	WAVETEK	23338	B420-421	1
12	INPUT CABLE	WAVETEK	23338	B398-008	2
13	I.D. PLATE	WAVETEK	23338	B147-334	1
14	BAG, ACCESSORY	WAVETEK	23338	B420-362	1
15					
16					
17					
18	POWER CORD (3)	HEWLETT - PACKARD	28480	8120-1369	2
19	PENCIL	STAEDTLER MARS		108-2	1
20	NUT, SELF LOCKING	SPS	56878	21FKF-616	2
21	POP RIVER (1/8 GRIP)	USM	07707	AD32-ABS	18
22	HANDLE, BLACK (NICKEL PLATED)	PHILADELPHIA HANDLE CO.	12136	3150-305-304	1
23	MTG FOOT	ROYAL IND.	98388	2097W-475	9
24	WASHER, FLAT #6 NYLON	YOML			12

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN	DATE	WAVETEK
MATERIAL	PROJENGR		TITLE: ASSEMBLY TRANSMISSION LEVEL TEST SET
FINISH WAVETEK PROCESS	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ± 1 XX ± .030		
	DO NOT SCALE DWG		MODEL NO 420-3-47 DWG NO B398-000 REV
	SCALE		CUSTOMER 23338 SHEET 2 OF 2

B398-000

B420-420

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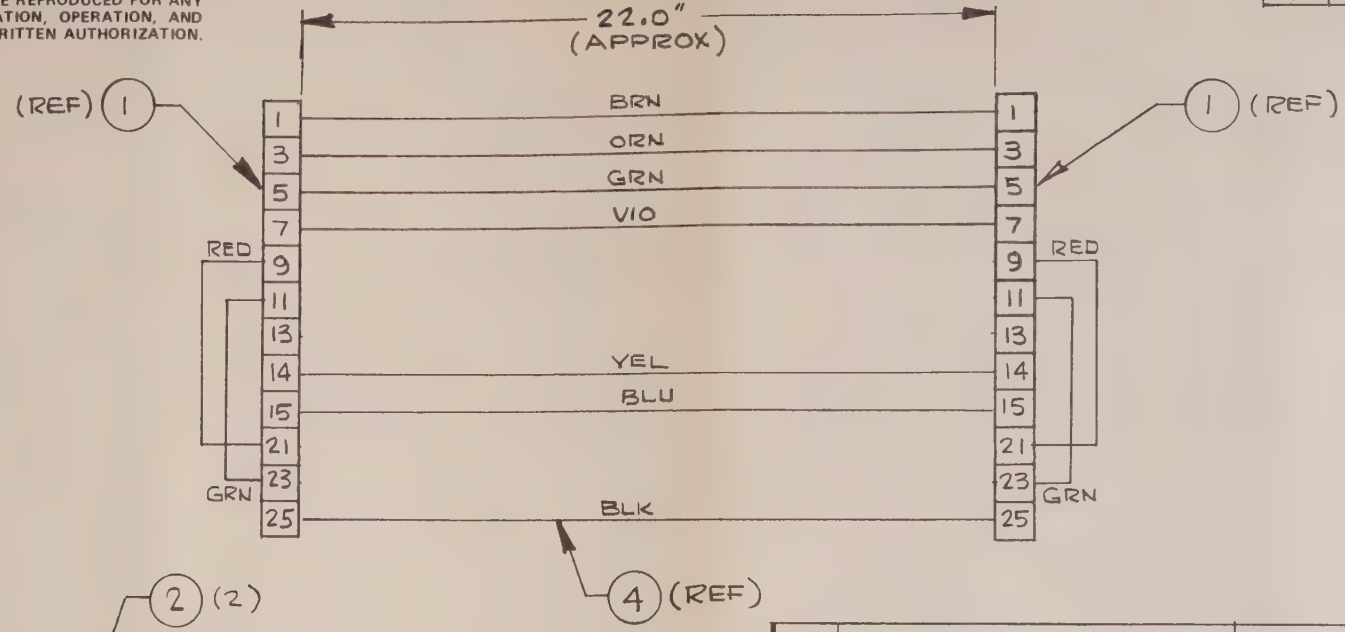
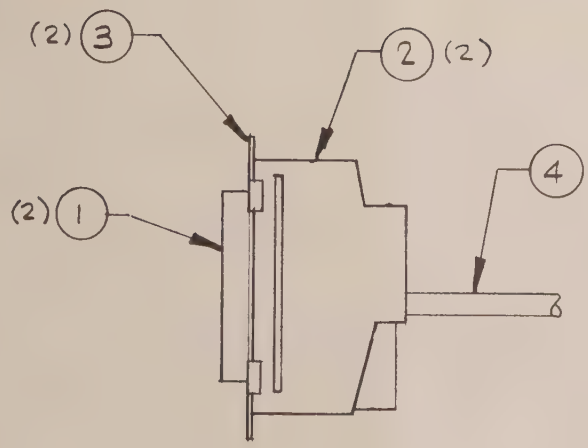
REV	ECN	BY	DATE	APP
A	ECN 773	BA	11-5-73	





LINE NO.	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
4	CABLE, 12 CONDUCTOR	BELDEN	16428	8457	24"
3	END DISC LATCH	CANNON	31746	D110278	2
2	JUNCTION SHELL	CANNON	31746	DB-51212-1	2
1	CONNECTOR (25 PIN)	CANNON	31746	DBC-25P	2

PARTS LIST

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES

MATERIAL —//—

FINISH WAVETEK PROCESS —//—

DRAWN B. REDMAN DATE 6-5-73

PROJ ENGR 6/25/73

RELEASE APPROV

TOLERANCE UNLESS OTHERWISE SPECIFIED
.XXX ±.010 ANGLES ±1°
.XX ±.030

DO NOT SCALE DWG

SCALE —//—

WAVETEK SAN DIEGO • CALIFORNIA

TITLE
CABLE,
INTERCONNECT

MODEL NO. 420

DWG NO. B420-420

REV A

CODE IDENT 23338

SHEET 1 OF 1

B420-421

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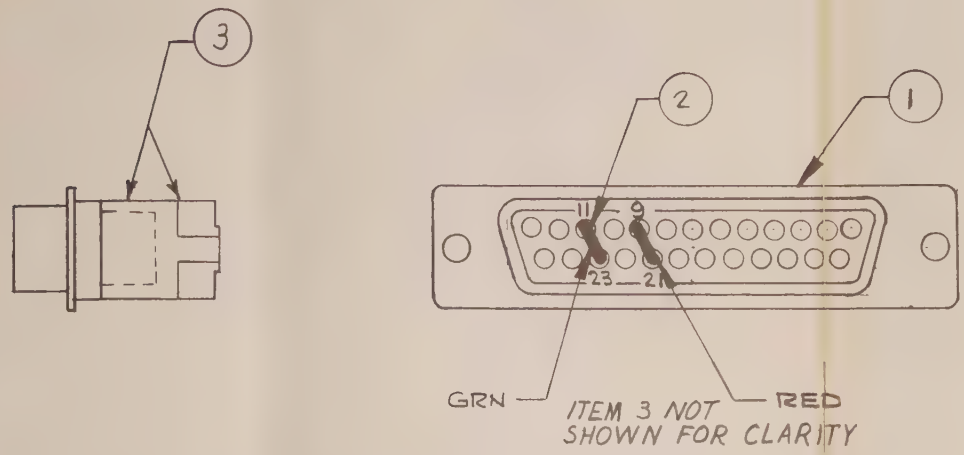
REV	ECN	BY	DATE	APP
A	#732	BA	9/14/73	



LINE NO.	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
3	JUNCTION SHELL	CANNON	31746	DB-51212-1	1
2	WIRE # 22AWG	COML			1½"
1	CONNECTOR (25 PIN)	CANNON	31746	DBC-25P	1

PARTS LIST

REMOVE ALL BURRS AND BREAK SHARP EDGES

MATERIAL —//—

FINISH WAVETEK PROCESS —//—

DRAWN B. REDMAN 6-5-73

PROJ ENGR [signature] 6/25/73

RELEASE APPROV

TOLERANCE UNLESS OTHERWISE SPECIFIED
.XXX ±.010 ANGLES ±1°
.XX ±.030

DO NOT SCALE DWG

SCALE 2/1

WAVETEK SAN DIEGO • CALIFORNIA

TITLE
INTERLOCK CONNECTOR
(TRANSMITTER)

MODEL NO. 420

DWG NO. B420-421

REV A

CODE IDENT 23338

SHEET 1 OF 1

NOTE: UNLESS OTHERWISE SPECIFIED

800-86E

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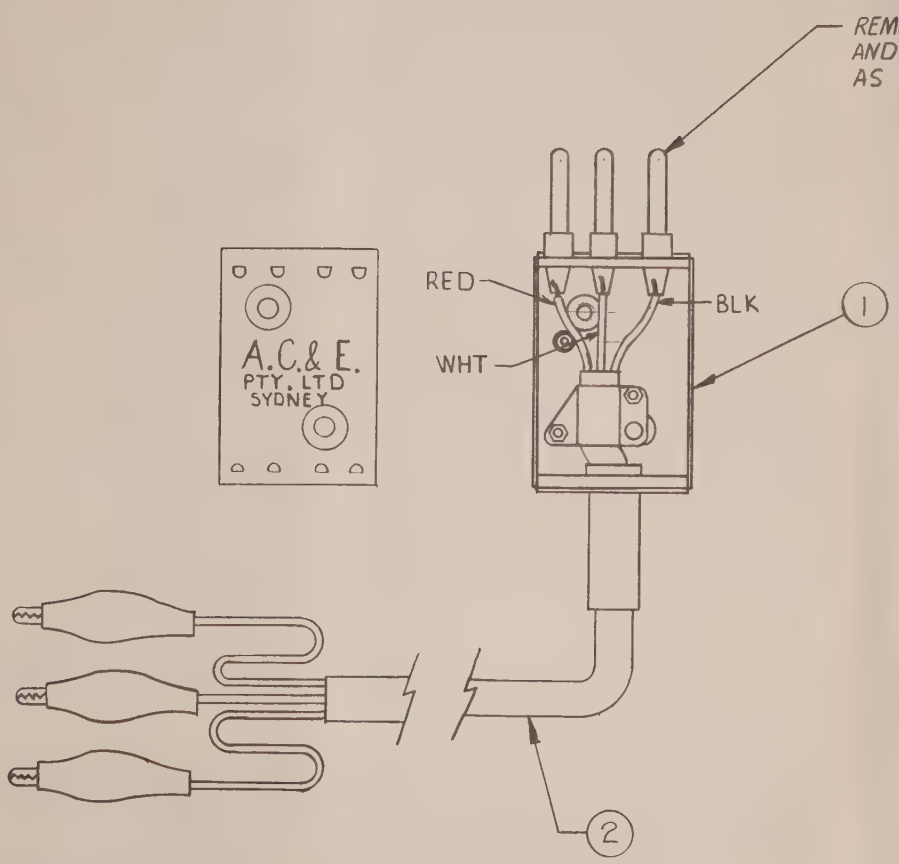
REV	ECN	BY	DATE	APP



NOTE: UNLESS OTHERWISE SPECIFIED

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR PN	QTY
2	CABLE, INPUT	WAVETEK	23338	B398-502	2
1	PLUG	A.C. & E		3001	1

REMOVE ALL BURRS AND BREAK SHARP EDGES

MATERIAL

FINISH
WAVETEK PROCESS

DRAWN BARNETT DATE 3-28-74

PROJ ENGR DATE 4/25/74

RELEASE APPROV

TOLERANCE UNLESS OTHERWISE SPECIFIED
.XXX ±.010 ANGLES ±1°
.XX ±.030

DO NOT SCALE DWG

SCALE FULL

WAVETEK SAN DIEGO • CALIFORNIA

TITLE
CABLE ASSY,
INPUT

MODEL NO. 420-S-438

DWG NO. 398-008

REV

CODE IDENT 23338

SHEET 1 OF 1

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REV	ECN	BY	DATE	APP

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
1	FRONT PANEL	WAVETEK	23338	C398-300	1
2	SUB PANEL	WAVETEK	23338	C398-302	1
3	CHASSIS ASSY, HORIZ	WAVETEK	23338	C420-319	1
4	CHASSIS, VERT	WAVETEK	23338	C420-320	1
5	REAR PANEL	WAVETEK	23338	C420-318	1
6	BAR, SUPPORT	WAVETEK	23338	A420-323	1
7	BRACKET, BATTERY	WAVETEK	23338	C420-322	1
8	BATTERY ASSY	WAVETEK	23338	C420-004	1
9	INDICATOR	WAVETEK	23338	B110-338	1
10	CAPACITOR	AMERICAN RADIONICS	07994	A420-505-81	1
11					
12	MAIN BOARD	WAVETEK	23338	0398-005	1
13	SWEEP GENERATOR BD	WAVETEK	23338	D420-018	1
14	BATTERY CHARGER BD	WAVETEK	23338	D420-010	1
15	ATTENUATOR ASSY	WAVETEK	23338	D420-011	1
16	S.F. BLANKING ASSY	WAVETEK	23338	D421-020	1
17	POTENTIOMETER	WAVETEK	23338	A420-410	1
18	TRANSFORMER	WAVETEK	23338	110-500	1
19	POTENTIOMETER	WAVETEK	23338	131-R1	1
20	DIAL BLANK	WAVETEK	23338	130-333	1
21	DIAL KNOB	WAVETEK	23338	130-325	1
22	FUSE 1/8 AMP S.B.	LITTELFUSE	75915	313.125	1
23	BINDING POST	SUPERIOR	58474	DF21BC	3
24	A.C. POWER RECEPTACLE	SWITCHCRAFT	82389	EAC-301	1
25	FUSE HOLDER	LITTLEFUSE	75915	342012	1
26	FUSE BLOCK	LITTLEFUSE	75915	357002	1
27	FUSE 1/4 AMP S.B.	LITTLEFUSE	75915	313.250	2
28	LED	OPCOA		OSL-6L-1	1

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
29	SWITCH 115/230	SWITCHCRAFT	82389	46256LF	1
30	SWITCH DPDT	C & K	09353	7201-PDCN	1
31	SWITCH SPDT	C & K	09353	7101-PDCN	1
32	LED MTG KIT	OPCOA		OC1	1
33	SOLDER LUG	H.H. SMITH	83330	1414-4	4
34	HOLDING COIL	WAVETEK	23338	B420-525	1
35	DIODE, ZENER	I.R.	81483	1N4744	2
36	GUARD SOLDER	SWITCHCRAFT	82389	46256LF-SG	1
37	RECEPTACLE	AC & E		3081	3
38	SWITCH (ON OFF MOMENTARY)	C & K	09353	7207-PDCN	1
39	SPRING LATCH ASSY	CANNON	91746	DD110277	1
40	TRANSISTOR	T.I.	01295	TIP 30	1
41	GROMMET	H.H. SMITH	83330	2175	4
42	KNOB, SKIRTED BAR	RAYTHEON	94144	70B-3-2G	2
43	KNOB, SKIRTED	RAYTHEON	94144	70-38L-2G	1
44	SHORTING BAR	SUPERIOR	58474	938-L	1
45	SPEED NUT	TINNERMAN	78553	C880-632	9
46					
47	SCREW, SELF LOCKING	LONG-LOK	16941	LP-35206-227	18
48	SCREW, 86-32 X 1 1/2 LONG	COML			4
49	NUT, SELF LOCKING 84-40	SPS	56878	21FA-440	7
50	NUT, SELF LOCKING 86-32	SPS	56878	21FA-632	9
51	STANDOFF	USECO		1531A 1/4-11	4
52					
53	SCREW, 82° F.H. 82-56 X 5/8	COML			3

B398-001

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN ADKING	DATE	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	PROJENGR McGuire	Mech	TITLE ASSEMBLY TRANSMITTER (UNIT)
FINISH WAVETEK PROCESS	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ± 1 XX ± .030		
	DO NOT SCALE DWG		MODEL NO 420-S-43[illegible] DWG NO B398-001 REV
	SCALE		CODE IDENT 23338 SHEET 2 OF 2

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REV	ECN	BY	DATE	APP

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
1	CAPACITORS				
2	CERAMIC DISC 1000V 10PF	CRL	71590	DD100	1
3	CERAMIC DISC 1000V 33PF	CRL	71590	DD330	2
4	CERAMIC DISC 1000V 47PF	CRL	71590	DD470	6
5					
6					
7	CERAMIC DISC 1000V 330PF	CRL	71590	DD331	1
8	CERAMIC DISC 1000V 220PF	CRL	71590	DD221	2
9	SILVER MICA 500V 1% 910PF	ARCO	02799	DM15-911F	3
10					
11	CERAMIC DISC 1000V 10%.001µF	CRL	71590	DD102	4
12	CERAMIC DISC 50V 10%.005µF	CRL	71590	CK502	2
13	CERAMIC DISC 1000V 10% .01µF	CRL	71590	CK103	2
14	MYLAR 2.15µF ±1%	AMERICAN RADIONICS	07994	WAVETEK 2MFW-205K (-82)	1
15					
16	TANTALUM, 35V 27µF	SPRAGUE	56289	196D276X0035F6	6
17					
18					
19					
20					
21					
22	DIODES				
23	DIODES 6.4V, ZENER	DICKSON	12954	IN4581	1
24	DIODES FD6666	FAIRCHILD	33888	FD6666	7
25	DIODES (MATCHED SET)	DICKSON	12954	IN4581 (-83)	2
26					
27					
28	INTEGRATED CIRCUITS				

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
29	INTEGRATED CIRCUITS µA709C	FAIRCHILD	33888	µA709 (-14)	4
30	INTEGRATED CIRCUITS LM301AN	NATIONAL	27014	LM301AN	2
31	INTEGRATED CIRCUITS CA3019	RCA	86684	CA3019	2
32					
33					
34					
35	POTENTIOMETERS				
36	POTENTIOMETERS 100Ω	BECKMAN	80740	91AR100Ω	1
37	POTENTIOMETERS 1K	BECKMAN	80740	91AR1K	3
38	POTENTIOMETERS 5K	BECKMAN	80740	91AR5K	5
39	POTENTIOMETERS 10K	BECKMAN	80740	91AR10K	2
40	POTENTIOMETERS 100K	BECKMAN	80740	91AR100K	4
41	POTENTIOMETERS 500Ω	BECKMAN	80740	91AR500Ω	1
42					
43					
44	TRANSISTORS				
45	TRANSISTORS 2N2219A	MOTOROLA	04713	2B2219A	1
46	TRANSISTORS 2N2905A	FAIRCHILD	33888	2N2905A	1
47	TRANSISTORS 2N3638	FAIRCHILD	33888	2N3638	2
48	TRANSISTORS 2N5458	MOTOROLA	04713	2N5458	1
49	TRANSISTORS 2N5461	MOTOROLA	04713	2N5461	1
50	TRANSISTORS	TECH PROD		TP605	1
51					
52					
53					
54	TRANSFORMER				
55	TRANSFORMER 61469	WAVETEK	23338	B398-500	1
56					
57					

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
58					
59	RESISTORS				
60	METAL FILM 1/8W 1% 10Ω	CORNING	16299	RN55D	8
61	METAL FILM 1/4W 1% 49.9Ω	CORNING	16299	RN60D	3
62	METAL FILM 1/8W 1% 100Ω	CORNING	16299	RN55D	3
63	METAL FILM 1/8W 1% 121Ω	CORNING	16299	RN55D	1
64	METAL FILM 1/8W 1% 124Ω	CORNING	16299	RN55D	1
65	METAL FILM 1/8W 1% 200Ω	CORNING	16299	RN55D	1
66	METAL FILM 1/8W 1% 301Ω	CORNING	16299	RN55D (-79)	2
67	METAL FILM 1/8W 1% 316Ω	CORNING	16299	RN55D	3
68	METAL FILM 1/8W 1% 499Ω	CORNING	16299	RN55D	2
69	METAL FILM 1/8W 1% 604Ω	CORNING	16299	RN55D (-80)	2
70	METAL FILM 1/8W 1% 750Ω	CORNING	16299	RN55D	1
71	METAL FILM 1/8W 1% 301Ω	CORNING	16299	RN55D (-85)	1
72	METAL FILM 1/8W 1% 604Ω	CORNING	16299	RN55D (-86)	1
73	METAL FILM 1/8W 1% 1.00K	CORNING	16299	RN55D	4
74	METAL FILM 1/8W 1% 1.21K	CORNING	16299	RN55D	1
75	METAL FILM 1/8W 1% 1.50K	CORNING	16299	RN55D	6
76					
77	METAL FILM 1/8W 1% 2.00K	CORNING	16299	RN55D	2
78	METAL FILM 1/8W 1% 2.49K	CORNING	16299	RN55D	2
79	METAL FILM 1/8W 1% 3.32K	CORNING	16299	RN55D	6
80					
81	METAL FILM 1/8W 1% 4.02K	CORNING	16299	RN55D	1
82	METAL FILM 1/8W 1% 4.32K	CORNING	16299	RN55D	4
83	METAL FILM 1/8W 1% 4.99K	CORNING	16299	RN55D	2
84	METAL FILM 1/8W 1% 6.98K	CORNING	16299	RN55D	1
85	METAL FILM 1/8W 1% 8.87K	CORNING	16299	RN55D	1

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN BARNETT	DATE 3-21-79	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	INSPECTOR		TITLE ASSEMBLY- MAIN BOARD TRANSMITTER
	RELEASE APPROV		
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ±.010 ANGLES ±1 XX ±.030		
	DO NOT SCALE DWG		MODEL NO 420-S-438 DWG NO B398-005 REV A
	SCALE		CODE IDENT 23338 SHEET 2 OF 3

B398-005 A

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REV	ECN	BY	DATE	APP

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
86	METAL FILM 1/8W 1% 9.53K	CORNING	16299	RN55D	1
87	METAL FILM 1/8W 1% 10.0K	CORNING	16299	RN55D	6
88	METAL FILM 1/8W 1% 12.1K	CORNING	16299	RN55D	1
89	METAL FILM 1/8W 1% 13.0K	CORNING	16299	RN55D	1
90	METAL FILM 1/8W 1% 21.5K	CORNING	16299	RN55D	1
91	METAL FILM 1/8W 1% 24.9K	CORNING	16299	RN55D	1
92	METAL FILM 1/8W 1% 30.1K	CORNING	16299	RN55D	2
93	METAL FILM 1/8W 1% 46.4K	CORNING	16299	RN55D	6
94	METAL FILM 1/8W 1% 49.9K	CORNING	16299	RN55D	2
95	METAL FILM 1/8W 1% 90.9K	CORNING	16299	RN55D	1
96	METAL FILM 1/8W 1% 124K	CORNING	16299	RN55D	1
97	METAL FILM 1/8W 1% 221K	CORNING	16299	RN55D	1
98	METAL FILM 1/8W 1% 237K	CORNING	16299	RN55D	1
99	METAL FILM 1/4W 1% 1M	CORNING	16299	RN60D	1
100	CARBON 1/2W 5% 10M	STACKPOLE	29604	RC20GF	1
101	METAL FILM 1/8W 1% 1.78K	CORNING	16299	RN55D	1
102	METAL FILM 1/8W 1% 27.4K	CORNING	16299	RN55D	1
103	RESISTOR MATCHED SETS 10.0K	CORNING	16299	RN55D (-64)	6
104	RESISTOR MATCHED SETS 15.8K	CORNING	16299	RN55D (-76)	2
105	RESISTOR MATCHED SETS 46.4K	CORNING	16299	RN55D (-77)	2
106	RESISTOR MATCHED SETS 110K	CORNING	16299	RN55D (-78)	2
107	METAL FILM 1/8W 100K	CORNING	16299	RN55D	2
108					
109	SWITCHES				
110	SWITCHES	WAVETEK	23338	B420-403	1
111	SWITCHES	WAVETEK	23338	B750-400	2
112	SWITCHES	WAVETEK	23338	B198-501	1
113	CONNECTOR 25 PIN	CANNON	71468	DBC25S	1
114					

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
115	MTG BLOCK	PANDUIT	06383	TM-256C	2
116	TRANSISTOR PAD	MILTON ROSS	07047	10123N	4
117	SWAGE STANDOFF	AMOTOM	06540	9531B-B-0440-3A	2
118	AMP PINS	AMP	00779	61182-2	25
119					
120	TIE STRAP	PANDUIT	06383	SST-1.5M	2
121					
122	CIRCUIT BOARD	WAVETEK	23338	398-105A	1

LINE ITEM REFERENCE LIST

REF DES	P/L LINE
C1	12
C2	8
C3	16
C4	3
C5	12
C6	8
C7	16
C8	9
C9	9
C10	9
C11	11
C12	3
C13	11
C14	4
C15	4
C16	13
C17	13
C18	11
C19	4
C20	4
C21	11
C22	2
C23	4
C24	7
C25	16
C26	16
C27	4
C28	14
C29	16
C30	16
CR1	23
CR2	24
CR3	24
CR4	25
CR5	25
CR6	24
CR7	24
CR8	24
CR9	24
CR10	24
IC1	29
IC2	30
IC3	29
IC4	30
IC5	29
IC6	31
IC7	29
IC8	31

LINE ITEM REFERENCE LIST

REF DES	P/L LINE
Q1	48
Q2	49
Q3	47
Q4	50
Q5	47
Q6	45
Q7	46
R1	38
R2	38
R3	36
R4	38
R5	38
R6	40
R7	37
R8	36
R9	40
R10	36
R11	41
R12	40
R13	37
R14	37
R15	79
R16	79
R17	86
R18	75
R19	85
R20	87
R21	73
R22	75
R23	77
R24	103
R25	82
R26	76
R27	87
R28	87
R29	93
R30	103
R31	53
R32	93
R33	100
R34	82
R35	98
R36	93
R37	90
R38	84
R39	63
R40	87
R41	74
R42	85
R43	62

LINE ITEM REFERENCE LIST

REF DES	P/L LINE
R44	82
R45	77
R46	77
R47	77
R48	77
R49	77
R50	82
R51	82
R52	94
R53	94
R54	77
R55	77
R56	77
R57	77
R58	134
R59	60
R60	60
R61	133
R62	104
R63	103
R64	85
R65	136
R66	104
R67	104
R68	106
R69	84
R70	133
R71	61
R72	93
R73	89
R74	85
R75	94
R76	95
R77	76
R78	61
R79	88
R80	78
R81	87
R82	86
R83	75
R84	95
R85	62
R86	79
R87	79
R88	60
R89	60
R90	68
R91	61
R92	61
R93	68
R94	70

LINE ITEM REFERENCE LIST

REF DES	P/L LINE
R95	97
R96	102
R97	93
R98	94
R99	96
R100	64
R101	69
R102	69
R103	68
R104	101
R105	71
R106	72
R107	78
R108	60
R109	60
R110	60
R111	60
R112	60
R113	107
R114	38
R115	87
R116	40
R117	107
R118	79
SW1	111
SW2	111
SW3	111
SW4	111
SW5	110
SW6	110
SW7	110
SW8	110
SW9	110
SW10	109
SW11	109
SW12	110
SW13	110
SW14	112
T1	55

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN BARNETT	DATE 6/6/77	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	PROJECT ENGR	TITLE	ASSEMBLY - MAIN BOARD TRANSMITTER
FINISH WAVETEK PROCESS	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ± 1 XX ± .030		
	DO NOT SCALE DWG	MODEL NO 420-S-938	DWG NO B398-005 REV A
	SCALE	CAGE NUMBER 23338	SHEET 3 OF 3

B398-005-1A

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REV	ECN	BY	DATE	APP

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
1	RESISTORS				
2	METAL FILM, 1/8W, 1%, 10Ω	CORNING	16299	RN55D	2
3	METAL FILM, 1/8W, 1%, 21.5Ω	CORNING	16299	RN55D	1
4	METAL FILM, 1/8W, 1%, 39.2Ω	CORNING	16299	RN55D	2
5	METAL FILM, 1/8W, 1%, 46.4Ω	CORNING	16299	RN55D	1
6	METAL FILM, 1/8W, 1%, 54.9Ω	CORNING	16299	RN55D	1
7	METAL FILM, 1/8W, 1%, 90.9Ω	CORNING	16299	RN55D	1
8	METAL FILM, 1/8W, 1%, 124Ω	CORNING	16299	RN55D	1
9	METAL FILM, 1/8W, 1%, 150Ω	CORNING	16299	RN55D	1
10	METAL FILM, 1/8W, 1%, 182Ω	CORNING	16299	RN55D	1
11	METAL FILM, 1/8W, 1%, 200Ω	CORNING	16299	RN55D	2
12	METAL FILM, 1/8W, 1%, 249Ω	CORNING	16299	RN55D	1
13	METAL FILM, 1/8W, 1%, 274Ω	CORNING	16299	RN55D	2
14	METAL FILM, 1/8W, 1%, 301Ω	CORNING	16299	RN55D	3
15	METAL FILM, 1/8W, 1%, 316Ω	CORNING	16299	RN55D	1
16	METAL FILM, 1/8W, 1%, 332Ω	CORNING	16299	RN55D	2
17	METAL FILM, 1/8W, 1%, 464Ω	CORNING	16299	RN55D	1
18	METAL FILM, 1/8W, 1%, 499Ω	CORNING	16299	RN55D	1
19	METAL FILM, 1/8W, 1%, 511Ω	CORNING	16299	RN55D	1
20	METAL FILM, 1/8W, 1%, 523Ω	CORNING	16299	RN55D	1
21	METAL FILM, 1/8W, 1%, 909Ω	CORNING	16299	RN55D	1
22	METAL FILM, 1/8W, 1%, 3.01K	CORNING	16299	RN55D	1
23	METAL FILM, 1/8W, 1%, 4.99K	CORNING	16299	RN55D	1
24	METAL FILM, 1/8W, 1%, 9.53K	CORNING	16299	RN55D	1
25					
26					
27	SWITCH ASSEMBLY	WAVETEK	23338	A420-406	1

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
28	SWITCH ASSEMBLY	WAVETEK	23338	A420-407	1
29					
30	AMP PINS	AMP	00779	61182-2	6
31	CIRCUIT BOARD	WAVETEK	23338	420-111E	1
32					
33					
34					
35					
36					
37					
38					
39					
40					

LINE ITEM REFERENCE LIST

REF DES	P/L LINE	REF DES	P/L LINE	REF DES	P/L LINE
R1	24	R21	18		
R2	10	R22	11		
R3	22	R23	13		
R4	4	R24	14		
R5	21	R25	7		
R6	4	R26	14		
R7	13	R27	6		
R8	2	R28	14		
R9	9	R29	5		
R10	8	R30	12		
R11	23				
R12	3				
R13	2				
R14	17				
R15	15	SW1	27		
R16	19	SW2	28		
R17	11				
R18	16				
R19	16				
R20	20				

REMOVE ALL BURRS AND BREAK SHARP EDGES

MATERIAL

FINISH WAVETEK PROCESS

DRAWN M. BOCHICHIO DATE 5-16-73

ENGINEER Signature 6/75

RELEASE APPROV

TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ± 1° XX ± .030

DO NOT SCALE DWG

SCALE

WAVETEK SAN DIEGO, CALIFORNIA

TITLE ASSEMBLY ATTENUATOR (TRANSMITTER)

MODEL NO 420

DWG NO B420-011

REV F

CODE IDENT 23338

SHEET 2 OF 2

B420-011 F

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REV	ECN	BY	DATE	APP

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
1	CAPACITORS				
2	CERAMIC DISC 220PF	CRL	71590	DD221	3
3	CERAMIC DISC .005uF	CRL	71590	DD502	3
4					
5	CERAMIC DISC .01uF 50V	CRL	71590	CK103	1
6	MYLAR 200V 1uF	ELECTRO CUBE	14752	2108IC105F	1
7	TANTALUM 35V 27uF	SPRAGUE	56289	196D276X0035FB	2
8	POLYSTYRENE .1uF 100V	ELPAC		PA2B104F	1
9					
10	DIODES				
11	DIODE 6.4V ZENER	DICKSON	12954	IN4581	2
12	DIODE	FAIRCHILD	33888	FD6666	1
13	INTEGRATED CIRCUITS				
14	INTEGRATED CIRCUITS uA709C	FAIRCHILD	33888	uA709 (-14)	4
15	INTEGRATED CIRCUITS uA709C	FAIRCHILD	33888	uA709C (-44)	1
16					
17	POTENTIOMETERS				
18	POTENTIOMETER 5K	BECKMAN	80740	91AR5K	1
19	POTENTIOMETER 100K	BECKMAN	80740	91AR100K	2
20					
21	RELAY	ELECTROL		R4469-3	2
22	RESISTORS				
23	METAL FILM 1/8W 1% 10Ω	CORNING	16299	RN55D	2
24	METAL FILM 1/8W 1% 1.5K	CORNING	16299	RN55D	3
25	METAL FILM 1/8W 1% 3.32K	CORNING	16299	RN55D	2
26	METAL FILM 1/8W 1% 4.32K	CORNING	16299	RN55D	1
27	METAL FILM 1/8W 1% 4.99K	CORNING	16299	RN55D	4
28	METAL FILM 1/8W 1% 6.19K	CORNING	16299	RN55D	1
29	METAL FILM 1/8W 1% 10K	CORNING	16299	RN55D	8

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
30	METAL FILM 1/8W 1% 21.5K	CORNING	16299	RN55D	1
31	METAL FILM 1/8W 1% 30.1K	CORNING	16299	RN55D	1
32	METAL FILM 1/8W 1% 237K	CORNING	16299	RN55D	2
33	METAL FILM 1/8W 1% 19.1K	CORNING	16299	RN55D	1
34					
35	METAL FILM 1/4W 1% 49.9Ω	CORNING	16299	RN60D	1
36	METAL FILM 1/4W 1% 499K	CORNING	16299	RN60D	2
37	METAL FILM 1/4W 1% 432K	CORNING	16299	RN60D	2
38					
39	TRANSISTORS				
40	TRANSISTORS 2N3638	FAIRCHILD	33888	2N3638	2
41	TRANSISTORS 2N3642	FAIRCHILD	33888	2N3642	2
42	TRANSISTORS 2N2219	FAIRCHILD	33888	2N2219	1
43					
44					
45	AMP PINS	AMP	00779	61182-1	17
46	TRANSIPADS	MILTON ROSS	07047	10123N	5
47					
48					
49					
50	CIRCUIT BOARD	WAVETEK	23338	420-113	1

LINE ITEM REFERENCE LIST

REF DES	P/L LINE	REF DES	P/L LINE	REF DES	P/L LINE
C1	3	R23	23		
C2	2	R24	28		
C3	6	R25	23		
C4	3	R26	37		
C5	7	R27	29		
C6	7	R28	24		
C7	7	R29	27		
		R30	37		
C9	3	R31	27		
C10	2	R32	33		
		R33	27		
C12	8	R34	29		
		R35			
C14	5	R36			
CR1	11				
CR2	11				
CR3	12				
IC1	15				
IC2	14				
IC3	14				
IC4	14				
IC5	14				
K1	21				
K2	21				
Q1	41				
Q2	40				
Q3	41				
Q4	40				
Q5	42				
R1	19				
R2	19				
R3	18				
R4	25				
R5	25				
R6	32				
R7	31				
R8	32				
R9	26				
R10	24				
R11	30				
R12	28				
R13	29				
R14	29				
R15	36				
R16	24				
R17	36				
R18	35				
R19	25				
R20	29				
R21	27				
R22	29				

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN BARNETT	DATE 3-15-7	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	CHECKED		ASSEMBLY- SWEEP GENERATOR (TRANSMITTER)
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX .010 ANGLES 1° .XX .02		MODEL NO 420-S-438 DWG NO B420-018 REV
	DO NOT SCALE DWG		CODE IDENT 23338 SHEET 2 OF 2
	SCALE		

B420-018

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REV	ECN	BY	DATE	APP

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
1	CAPACITORS				
2	CERAMIC DISC 50V .005μF	CRL	71590	CK502	1
3	CERAMIC DISC 220PF	CRL	71590	DD221	1
4	TANTALUM .47μF	SPRAGUE	56289	150D474X9050B2	1
5	TANTALUM 10μF	SPRAGUE	56289	150D106X902B2	1
6	ELECTROLYTIC 50V 50μF	SPRAGUE	56289	500D506G05DD7	2
7	ELECTROLYTIC 75V 250μF	SPRAGUE	56289	39D257G075JE4	1
8					
9					
10	DIODE 6.4V ZENER	DICKSON	12954	IN4581	1
11	DIODE 100V G.P. SILICON	MOTOROLA	04713	IN4002	7
12	DIODE 100V G.P. SILICON	FAIRCHILD	33888	FD6666	8
13					
14					
15					
16	INTEGRATED CIRCUITS μA709	FAIRCHILD	33888	μA709 C (-14)	1
17	INTEGRATED CIRCUITS μA709	FAIRCHILD	33888	μA709C (-44)	1
18					
19					
20	TRANSISTOR 2N3642	FAIRCHILD	33888	2N3642	1
21	TRANSISTOR 2N3643	FAIRCHILD	33888	2N3643	2
22					
23	RESISTOR CARBON 1W 5% 470Ω	STACKPOLE	29604	RC32GF471J	1
24	METAL FILM 1/8W 1% 1K	CORNING	16299	RN55D	4
25	METAL FILM 1/8W, 1% 1.5K	CORNING	16299	RN55D	1
26	METAL FILM 1/8W 1% 10K	CORNING	16299	RN55D	2
27	METAL FILM 1/8W 1% 21.5K	CORNING	16299	RN55D	1
28	METAL FILM 1/8W 1% 49.9K	CORNING	16299	RN55D	2
29	METAL FILM 1/8W 1% 69.8K	CORNING	16299	RN55D	1
30	METAL FILM 1/8W 1% 100K	CORNING	16299	RN55D	1

PARTS LIST

LINE NO.	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
31	METAL FILM 1/8W 1% 301K	CORNING	16299	RN55D	1
32	POTENTIOMETER 100Ω	BECKMAN	80740	91AR100Ω	1
33	POTENTIOMETER 10K	BECKMAN	80740	91AR10K	1
34					
35					
36					
37					
38					
39	AMP PINS	AMP	00779	61182-2	25
40	CLAMP	SEASTROM	86928	4511-100-68-2C	1
41	TINNERMAN CLIPS	TINNERMAN	78553	C880-632	2
42	TERMINALS	USECO	88245	20008-1	4
43					
44	TRANSISTOR PAD	MILTON ROSS	07047	10123N	3
45	RESISTANCE WIRE 3/4"	WILBER DRIVER	72005	#30 AWG (3Ω PER FOOT)	1
46					
47					
48	CIRCUIT BOARD	WAVETEK	23338	420-110B	1
49					
50					
51					
52					
53					
54					
55					
56					
57					
58					
59					

LINE ITEM REFERENCE LIST

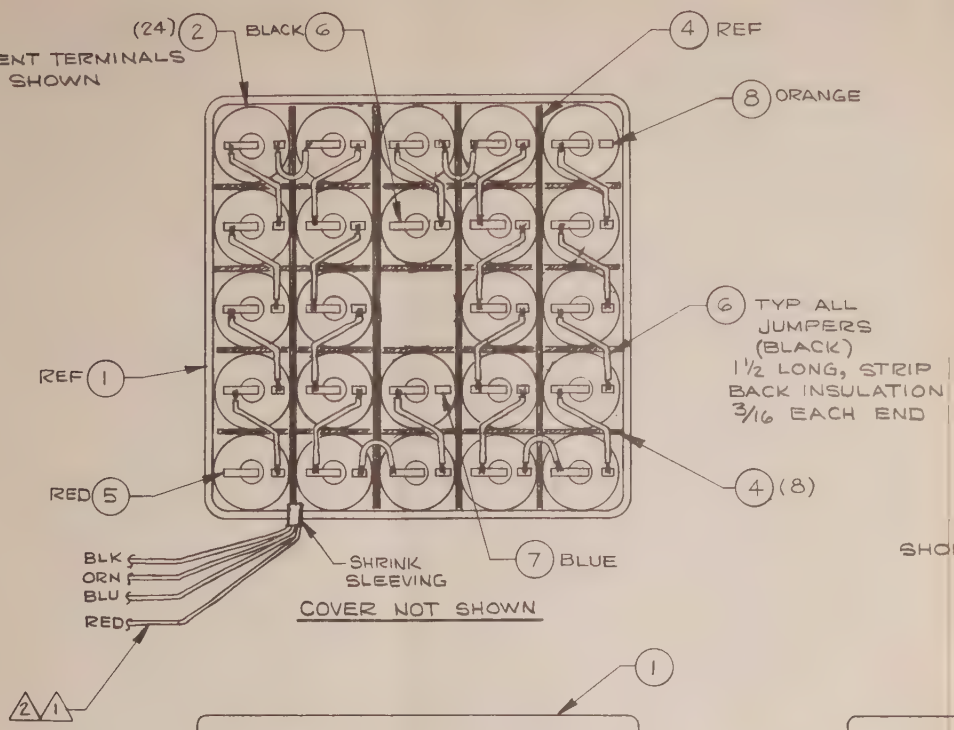
REF DES	P/L LINE	REF DES	P/L LINE	REF DES	P/L LINE
C1	6	R1	27		
C2	6	R2	26		
C3	7	R3	28		
C4	2	R4	32		
C5	3	R5	24		
C6	4	R6	25		
C7	5	R7	24		
		R8	24		
		R9	23		
CR1	11	R10	33		
CR2	11	R11	29		
CR3	11	R12	28		
CR4	11	R13	30		
CR5	11	R14	24		
CR6	11	R15	26		
CR7	10	R16	31		
CR8	12	R17	45		
CR9	12				
CR10	11				
CR11	12				
CR12	12				
CR13	12				
CR14	12				
CR15	12				
CR16	12				
IC1	17				
IC2	16				
Q1	20				
Q2	21				
Q3	21				

NOTE: UNLESS OTHERWISE SPECIFIED

BRUNING 40-320 15821

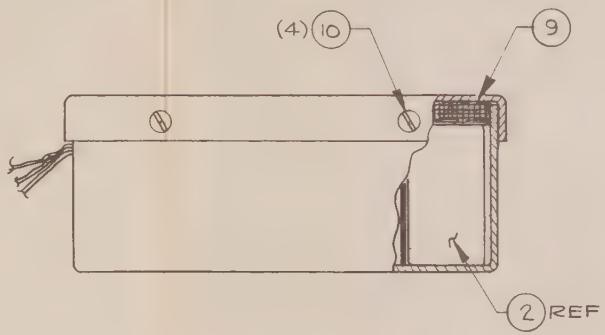
REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN M. BOCHICHIO	DATE 4/24/78	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	PROJ ENGR	7/13/78	TITLE ASSEMBLY BATTERY CHARGER BD (TRANSMITTER)
FINISH WAVETEK PROCESS	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ± 010 ANGLES ±1° .XX ± 030		
	DO NOT SCALE DWG		MODEL NO. 420 DWG NO. B420-010 REV F
	SCALE —		CODE IDENT 23338 SHEET 2 OF 2

B420-010 F



CAUTION

CHARGED BATTERIES, DO NOT SHORT CIRCUIT BATTERY TERMINALS



PARTS LIST

LINE NO.	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
1	BATTERY BOX	WAVETEK		B420-325	1
2	BATTERY	UNION CARBIDE		420-526	24
3					
4	SEPARATOR STRIP	WAVETEK		A420-352	8
5	WIRE, TEFLON #22AWG (RED)	ALFA		MIL-W-16878	A/R
6	(BLACK)				A/R
7	(BLUE)				A/R
8	(ORANGE)				A/R
9	FOAM	WAVETEK		A420-351	1
10	SCREW, SELF TAPPING FLAT HEAD (SLOTTED) #4-24 x 1/4 TYPE B(2)	COML		—	4
11	AMP PIN (FEMALE)	AMP		60539-8	4

2 AMP PINS (4) ON ENDS OF WIRE HARNESS MUST BE COMPLETLY COVERED WITH SHRINK SLEEVING, OR EQUIV, BEFORE HARNESS IS CONNECTED TO BATTERY PACK.

1 C420-004 – INSTALL WIRE HARNESS FOR TRANSMITTER INSTALLATION.
C420-005 – INSTALL WIRE HARNESS FOR RECEIVER INSTALLATION.

NOTES:

REV	ECN	BY	DATE	APP
C	ECN 773	BA	11-6-73	
B	REVISED ASSY	B.R.	6-11-73	
A	REVISED ASSY	B.R.	5-8-73	

TOLERANCE UNLESS OTHERWISE SPEC
.XXX ± .010
.XX ± .030
ANGLES ± 0°30'

WAVETEK SAN DIEGO, CALIF.

SCALE 1/1 | BY B. REDMAN | DATE 1-9-73 | APP

MATERIAL —

FINISH —

TITLE
BATTERY PACK ASSEMBLY

MODEL NO. 420 | DWG NO. C420-004 C420-005 | REV C

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REV	ECN	BY	DATE	APP

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
1	CAPACITORS				
2	CERAMIC DISC 33PF	CRL	71590	DD-330	1
3	CERAMIC DISC 220PF	CRL	71590	DD-221	2
4	CERAMIC DISC .005UF	CRL	71590	CK-502	3
5	TANTALUM 35V, 27UF	SPRAGUE	56289	196D276X0035FB	2
6					
7					
8	DIODE ZENER 6.4V	DICKSON	12954	1N4581	1
9					
10	INTEGRATED CKT	FCH	33888	UA709C	2
11	INTEGRATED CKT	FCH	33888	LM301AN	1
12	POTENTIOMETER 10K	BECKMAN	80747	91AR10K	2
13	RELAY FORM C	JENCO		RR30-1023	1
14	RESISTOR				
15	METAL FILM 1/8W 1% 51.1Ω	CORNING	16299	RN55D	2
16	METAL FILM 1/8W 1% 100Ω	CORNING	16299	RN55D	1
17	METAL FILM 1/8W 1% 1K	CORNING	16299	RN55D	6
18	METAL FILM 1/8W 1% 1.5K	CORNING	16299	RN55D	2
19	METAL FILM 1/8W 1% 3.32K	CORNING	16299	RN55D	1
20	METAL FILM 1/8W 1% 6.98K	CORNING	16299	RN55D	4
21	METAL FILM 1/8W 1% 100K	CORNING	16299	RN55D	4
22					
23					
24					
25	AMP PIN	AMP	00779	61182-1	9
26					
27	CIRCUIT BOARD	WAVETEK	23338	421-1208	1
28					
29					

LINE ITEM REFERENCE LIST

REF DES	P/L LINE	REF DES	P/L LINE	REF DES	P/L LINE
C1	5	R1	19		
C2	5	R2	15		
C3	2	R3	15		
C4	4	R4	17		
C5	3	R5	17		
C6	4	R6	20		
C7	4	R7	20		
C8	3	R8	21		
		R9	20		
CR1	8	R10	12		
		R11	17		
IC1	11	R12	21		
IC2	10	R13	20		
IC3	10	R14	12		
		R15	17		
K1	13	R16	18		
		R17	21		
		R18	18		
		R19	21		
		R20	16		
		R21	17		
		R22	17		

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES
MATERIAL
FINISH WAVETEK PROCESS
DRAWN BARNETT DATE 3-5
PROJ MGR
RELEASE APPROV
TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ±1 XX ± .030
DO NOT SCALE DWG
SCALE

WAVETEK SAN DIEGO • CALIFORNIA

TITLE
ASSEMBLY-
S.F. SUPPRESSION

MODEL NO 421
DWG NO B421-020
REV
CODE IDENT 23338
SHEET 2 OF 2

B421-020

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REV	ECN	BY	DATE	APP

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
1	FRONT PANEL	WAVETEK	23338	C398-301	1
2	SUB PANEL	WAVETEK	23338	C398-303	1
3	REAR PANEL	WAVETEK	23338	C420-326	1
4	CHASSIS, HORIZ	WAVETEK	23338	D420-327	1
5	CHASSIS, VERT	WAVETEK	23338	C420-328	1
6	ENCLOSURE, H.V.	WAVETEK	23338	C420-329	1
7	COVER, ENCLOSURE	WAVETEK	23338	B420-330	1
8	BRACKET, POT MTG	WAVETEK	23338	C420-331	1
9	SUPPORT BAR	WAVETEK	23338	B420-332	1
10	SIDE PLATE	WAVETEK	23338	C420-344	1
11	CRT ASSEMBLY	WAVETEK	23338	D420-042	1
12					
13					
14					
15	MAIN BOARD	WAVETEK	23338	D398-006	1
16	HIGH VOLTAGE BD	WAVETEK	23338	D420-019	1
17	ATTENUATOR BD	WAVETEK	23338	D420-022	1
18	INTERFACE BD	WAVETEK	23338	420-117A	1
19	HOLDING COIL	WAVETEK	23338	B420-525	1
20	POTENTIOMETER 100Ω	WAVETEK	23338	A420-522	1
21	POTENTIOMETER 10K	WAVETEK	23338	A420-523	2
22	POTENTIOMETER 100K	WAVETEK	23338	A420-524	1
23					
24					
25					
26	DIODE, ZENER	R	81483	1N4744	2
27					
28	CONNECTOR	CANNON	31746	DBC-25P	1

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
[illegible]	LED	[illegible]		OSL-6L-1	5
10	SWITCH DPDT	[illegible]	09353	7201-PDCN	1
11	SWITCH SPDT	[illegible]	09353	7101-PDCN	1
12	LABEL, DANGER HIGH VOLTAGE	BRADY	85480	8513472-1	1
13	TUBE, SOCKET (7 PIN)	INTERNATIONAL IMPORTS		57-502B	1
14	RECEPTACLE	AC & E		3081	2
15	LED MTG KIT	[illegible]		OC1	5
16	SPRING LATCH ASSY	CANNON	31746	0110277	2
17	GROMMET	H.H. SMITH	83330	2175	5
18	KNOB, SKIRTED BAR	RAYTHEON	94144	70B-3-2G	2
19	SPEED NUT	TINNERMAN	78553	C880-632	16
40	AMP PIN (MALE)	AMP	00779	61182-2	46
41					
42					
43					
44	SCREW, 82° F.H. #2-56 X 5/8	COML			2
45	SCREW, SELF LOCKING #6-32 X 5/16	LONG-LOK	16941	LP-35206-227	16
46	NUT, SELF LOCKING #4-40	SPS	56878	21-FA-440	4
47	NUT, SELF LOCKING #6-32	SPS	56878	21-FA-632	9

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN ATKINS	DATE [illegible]	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	[illegible]	[illegible]	ASSEMBLY RECEIVER (UNIT 2)
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX .010 ANGLES ±1 XX .030		
	DO NOT SCALE DWG	MODEL NO 420-S-435	DWG NO D398-002 REV
	SCALE	CODE IDENT 23338	SHEET 2 OF 2

D398-002

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REV	ECN	BY	DATE	APP

PARTS LIST

LINE NO.	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
1	CAPACITORS				
2	CERAMIC DISC, 22PF	CRL	71590	DD220	1
3	CERAMIC DISC, 47PF	CRL	71590	DD470	7
4					
5	CERAMIC DISC, 220PF	CRL	71590	DD221	4
6					
7					
8	CERAMIC DISC, 1000V .001μF	CRL	71590	DD102	5
9	CERAMIC DISC, 50V, .005μF	CRL	71590	CK502	4
10	MYLAR, 100V, .01μF	IMB	27556	PA28103F	1
11	MYLAR 100V .1μF	SPRAGUE	56289	225PW	6
12					
13	MYLAR 200V, 10% 2μF	AMERICAN RADIONICS	07994	WAVETEK 2MFW 205K	1
14	TANTALUM 35V, 27μF	SPRAGUE	56289	196D276X0035FB	6
15	MYLAR 200V 3% 2.13μF	AMERICAN RADIONICS	07994	WAVETEK 2MFW-205K (-81)	1
16					
17					
18					
19	DIODES				
20	FD6666	FAIRCHILD	33888	FD6666	8
21	6.4V ZENER	DICKSON	12954	IN4581(-83)	2
22					
23	IN34	GENERAL ELECTRIC	09019	IN34	2
24					
25					
26					
27	INTEGRATED CIRCUITS				
28	INTEGRATED CIRCUITS μA709C	FAIRCHILD	33888	MA709 (-14)	10

PARTS LIST

LINE NO.	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
29					
30					
31					
32	POTENTIOMETERS				
33					
34	POTENTIOMETER 1K	BECKMAN	80740	91AR1K	2
35	POTENTIOMETER 5K	BECKMAN	80740	91AR5K	1
36	POTENTIOMETER 10K	BECKMAN	80740	91AR10K	2
37					
38					
39	RESISTORS				
40	METAL FILM 1/8W 1% 10Ω	CORNING	16299	RN55D	5
41	METAL FILM 1/8W 1% 31.6Ω	CORNING	16299	RN55D	1
42	METAL FILM 1/8W 1% 100Ω	CORNING	16299	RN55D	8
43	METAL FILM 1/8W 1% 150Ω	CORNING	16299	RN55D	1
44	METAL FILM 1/8W 1% 316Ω	CORNING	16299	RN55D	1
45	METAL FILM 1/8W 1% 464Ω	CORNING	16299	RN55D	1
46	METAL FILM 1/8W 1% 499Ω	CORNING	16299	RN55D	6
47	METAL FILM 1/8W 1% 681Ω	CORNING	16299	RN55D	2
48	METAL FILM 1/8W 1% 750Ω	CORNING	16299	RN55D	1
49	METAL FILM 1/8W 1% 8.87K	CORNING	16299	RN55D	1
50	METAL FILM 1/8W 1% 15.0K	CORNING	16299	RN55D	1
51	METAL FILM 1/8W 1% 1.00K	CORNING	16299	RN55D	4
52	METAL FILM 1/8W 1% 1.10K	CORNING	16299	RN55D	1
53	METAL FILM 1/8W 1% 1.21K	CORNING	16299	RN55D	1
54	METAL FILM 1/8W 1% 1.50K	CORNING	16299	RN55D	12
55	METAL FILM 1/8W 1% 3.01K	CORNING	16299	RN55D	2
56	METAL FILM 1/8W 1% 3.32K	CORNING	16299	RN55D	7

PARTS LIST

LINE NO.	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
57	METAL FILM 1/8W 1% 3.65K	CORNING	16299	RN55D	1
58	METAL FILM 1/8W 1% 4.99K	CORNING	16299	RN55D	3
59	METAL FILM 1/8W 1% 10.0K	CORNING	16299	RN55D	5
60	METAL FILM 1/8W 1% 12.1K	CORNING	16299	RN55D	1
61	METAL FILM 1/8W 1% 21.5K	CORNING	16299	RN55D	1
62	METAL FILM 1/8W 1% 19.1K	CORNING	16299	RN55D	2
63	METAL FILM 1/8W 1% 30.1K	CORNING	16299	RN55D	1
64	METAL FILM 1/8W 1% 49.9K	CORNING	16299	RN55D	6
65	METAL FILM 1/8W 1% 63.4K	CORNING	16299	RN55D	1
66	METAL FILM 1/8W 1% 124K	CORNING	16299	RN55D	2
67	METAL FILM 1/8W 1% MATCHED 10.0K	CORNING	16299	RN55D (-64)	2
68	METAL FILM 1/8W 1% 56.2K	CORNING	16299	RN55D	1
69	METAL FILM 1/8W 1% 124Ω	CORNING	16299	RN55D	1
70	METAL FILM 1/4W ±1% 1M	CORNING	16299	RN60D	2
71	CARBON 2W 5% 91 OHM	STACKPOLE	29604	RC42GF910J	1
72					
73					
74					
75					
76					
77	TRANSISTORS				
78	2N3642	FAIRCHILD	33888	2N3642	1
79	TIP 29	T.I.	01295	TIP29	2
80	TIP 30	T.I.	01295	TIP 30	2
81					
82					
83	TRANSFORMERS				
84	TRANSFORMER 61228	WAVETEK	23338	8420-509	1

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN BARNETT	DATE 3/27/71	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	ENGINEER	RELEASE APPROV	TITLE ASSEMBLY- MAIN BOARD RECEIVER
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ±.010 ANGLES ±1 XX ±.030		
	DO NOT SCALE DWG		MODEL NO 420-S-438 DWG NO B398-006 REV
	SCALE		COOL IDENT 23338 SHEET 2 OF 3

B398-006

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REV	ECN	BY	DATE	APP

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
85					
86					
87					
88	SWITCHES				
89	SWITCH ASSY	WAVETEK	23338	8420-402	
90	SWITCH ASSY	WAVETEK	23338	8420-401	1
91	SWITCH ASSY	WAVETEK	23338	8750-400	2
92					
93					
94					
95	AMP PINS	AMP	00779	61182-2	AR
96	TRANSISTOR PAD	MILTON ROSS	07047	10123N	1
97	CONNECTOR	CANNON	91468	DBC25S	1
98					
99	SWAGE STANDOFF	AMOTOM	06540	95318-B-0440-3A	6
100	TIE STRAP	PANDUIT	06383	SST-1.5M	2
101					
102					
103	MTG BLOCK	PANDUIT	06383	TM-256C	2
104	LOCK WASHER (SPLIT) #4	COML			4
105	CIRCUIT BOARD	WAVETEK	23338	398-106	1

LINE ITEM REFERENCE LIST

REF DES	LINE NO
CR1	21
CR2	22
CR3	20
CR4	20
CR5	20
CR6	20
CR7	20
CR8	20
CR9	20
CR10	20
CR11	20
CR12	20

LINE ITEM REFERENCE LIST

REF DES	LINE NO
R69	52
R70	53
R71	45
R72	46
R73	51
R74	49
R75	50
R76	54
R77	54
R78	42
R79	56

REF DES	LINE NO
SW1	81
SW2	81
SW3	81
SW4	81
SW5	81
SW6	81
SW7	80
SW8	86
SW9	84
SW10	85
SW11	83
SW12	82
T1	87

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN BARNETT	DATE 3-21-79	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	ENG APPR		TITLE ASSEMBLY - MAIN BOARD RECEIVER
FINISH WAVETEK PROCESS	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 XX ± .030 ANGLES ± 1		
	DO NOT SCALE DWG		MODEL NO 420-S-438 DWG NO 8398-006 REV
	SCALE		CODE IDENT 23338 SHEET 3 OF 3

8398-006

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REV	ECN	BY	DATE	APP

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
1	RESISTOR				
2	METAL FILM, 1/8W, 1%, 10Ω	CORNING	16299	RN55D	2
3	METAL FILM, 1/8W, 1%, 21.5Ω	CORNING	16299	RN55D	1
4	METAL FILM, 1/8W, 1%, 39.2Ω	CORNING	16299	RN55D	2
5	METAL FILM, 1/8W, 1%, 46.4Ω	CORNING	16299	RN55D	1
6	METAL FILM, 1/8W, 1%, 54.9Ω	CORNING	16299	RN55D	1
7	METAL FILM, 1/8W, 1%, 90.9Ω	CORNING	16299	RN55D	1
8	METAL FILM, 1/8W, 1%, 124Ω	CORNING	16299	RN55D	1
9	METAL FILM, 1/8W, 1%, 150Ω	CORNING	16299	RN55D	1
10	METAL FILM, 1/8W, 1%, 182Ω	CORNING	16299	RN55D	1
11	METAL FILM, 1/8W, 1%, 200Ω	CORNING	16299	RN55D	2
12	METAL FILM, 1/8W, 1%, 249Ω	CORNING	16299	RN55D	1
13	METAL FILM, 1/8W, 1%, 274Ω	CORNING	16299	RN55D	2
14	METAL FILM, 1/8W, 1%, 301Ω	CORNING	16299	RN55D	3
15	METAL FILM, 1/8W, 1%, 316Ω	CORNING	16299	RN55D	1
16	METAL FILM, 1/8W, 1%, 332Ω	CORNING	16299	RN55D	2
17	METAL FILM, 1/8W, 1%, 464Ω	CORNING	16299	RN55D	1
18	METAL FILM, 1/8W, 1%, 499Ω	CORNING	16299	RN55D	1
19	METAL FILM, 1/8W, 1%, 511Ω	CORNING	16299	RN55D	1
20	METAL FILM, 1/8W, 1%, 523Ω	CORNING	16299	RN55D	1
21	METAL FILM, 1/8W, 1%, 909Ω	CORNING	16299	RN55D	1
22	METAL FILM, 1/8W, 1%, 3.01K	CORNING	16299	RN55D	1
23	METAL FILM, 1/8W, 1%, 9.53K	CORNING	16299	RN55D	1
24					
25					
26					
27					
28	SWITCH ASSEMBLY	WAVETEK	23338	A420-406	1
29	SWITCH ASSEMBLY	WAVETEK	23338	A420-407	1

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
10					
31	AMP PINS	AMP	00779	61182-2	11
32					
33	CIRCUIT BOARD	WAVETEK	23338	420-111	1
34					

LINE ITEM REFERENCE LIST

REF DES	P/L LINE	REF DES	P/L LINE	REF DES	P/L LINE
R1	17				
R2	15				
R3	13				
R4	11				
R5	14				
R6	19				
R7	16				
R8	7				
R9	14				
R10	5				
R11	14				
R12	6				
R13	16				
R14	20				
R15	18				
R16	11				
R17	12				
R18	9				
R19	8				
R20	2				
R21	13				
R22	21				
R23	4				
R24	22				
R25	4				
R26	23				
R27	10				
R28	2				
R29	3				
SW1	28				
SW2	29				

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN	DATE	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	ENGINEER		TITLE: ASSEMBLY ATTENUATOR (2A2) RECEIVER
FINISH WAVETEK PROCESS	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ± 1 XX ± .030		
	DO NOT SCALE DWG		MODEL NO: 420 DWG NO: B420-022 REV
	SCALE		CODE IDENT NO: 23338 SHEET 2 OF 2

D420-022

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REV	ECN	BY	DATE	APP

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
1	CAPACITORS				
2	CERAMIC DISC .001μF	CRL	71590	DD102	1
3	CERAMIC DISC 6KV 470PF	SPRAGUE	56289	60GA-747	6
4	GAP CAP 1.5KV .01μF	CRL	71590	GAP-103	3
5	MYLAR 50V .22μF	TRW	84411	601PE	1
6	TANTALUM 35V 33μF	SPRAGUE	56289	196D336X9035TE4	1
7	MYLAR 200V .44μF	TRW	84411	X663F	1
8					
9					
10	DIODES				
11	FDH6666	FAIRCHILD	33888	FDH6666	4
12	SCM 30	SEMTECH	14099	SCM-30	4
13	IN4003	G.I.	15281	IN4003	1
14					
15					
16	POTENTIOMETERS				
17	POTENTIOMETERS 100K	BECKMAN	80747	91AR100K	1
18					
19	RESISTORS				
20	METAL FILM 1/8W 1% 24.9Ω	CORNING	16299	RN55D	1
21	METAL FILM 1/8W 1% 4.75K	CORNING	16299	RN55D	1
22	METAL FILM 1/8W 1% 1	CORNING	16299	RN55D	1
23	METAL FILM 1/8W 1% 56.2K	CORNING	16299	RN55D	1
24	METAL FILM 1/8W 1% 4.99K	CORNING	16299	RN55D	1
25	METAL FILM 1/8W 1% 10K	CORNING	16299	RN55D	1
26	METAL FILM 1/4W 1% 1M	CORNING	16299	RN60D	6
27	METAL FILM 1/4W 1% 432K	CORNING	16299	RN60D	1
28	TRANSFORMER	WAVETEK	23338	8420-502	1
29					

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
30	TRANSISTOR				
31	TIP 29	[illegible]	[illegible]	[illegible]	1
32	TIP 30	[illegible]	[illegible]	[illegible]	1
33	2N3642	FAIRCHILD	[illegible]	[illegible]	2
[illegible]					
[illegible]					
36	AMP PIN	AMP	00779	61182-1	1
37	SCREW #4-40 X 2 PAN HEAD			COML	2
38	NUT, SELF LOCKING	SPS	56878	21FA-440	2
39	GROMMET	H.H.SMITH	83330	2175	2
40	HIGH VOLTAGE CABLE	INTER IMPORTERS		C8508R	1
41	SILICONE RUBBER	DOW CORNING	71384	3140	AR
42	STANDOFF, HEX, SWAGE	USECO	88245	1531-B-3/8	2
43	WIRE, TEFLON 1 1/2" LONG BLK	NATIONAL	04569	NE1934U	6
[illegible]					
45	TRANSIPADS	MILTONE ROSS	07047	10123N	2
46	BRACKET, XFMR	WAVETEK	23338	A420-348	2
47	CIRCUIT BOARD	WAVETEK	23338	420-112H	1

LINE ITEM REFERENCE LIST

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	6						
[illegible]	7						
[illegible]	5						
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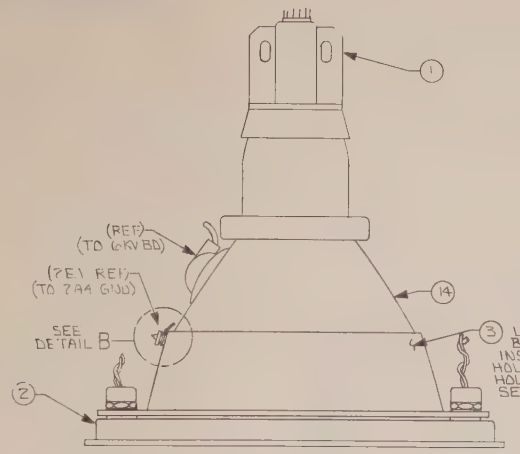
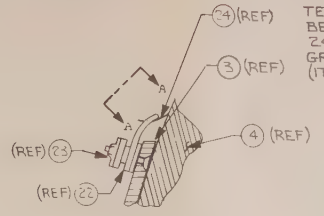
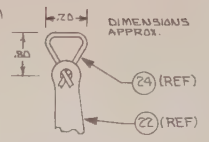
REV	ECN	BY	DATE	APP



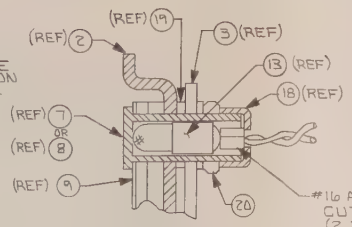


DETAIL B
SCALE: 2/1

TENSION SHOULD BE ON WIRE (ITEM 24) SO IT WILL GROUND TO CRT (ITEM 14)

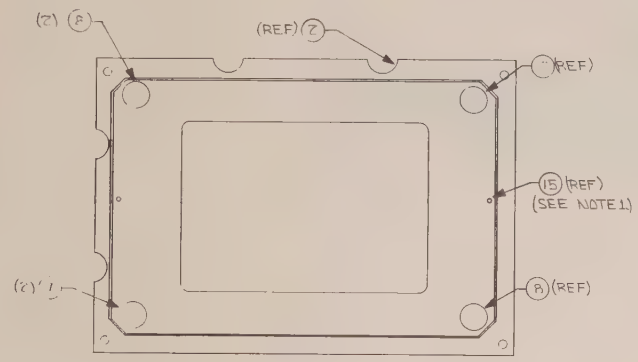


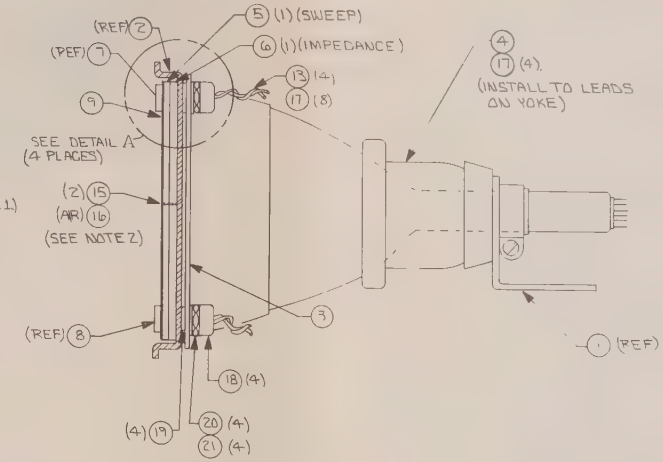
VIEW A-A



#16 AWG TEFLON TUBING CUT TO REQUIRED LENGTH (2 REQUIRED)

DETAIL A
SCALE: 2/1





PARTS LIST					
ITEM	DESCRIPTION	MFGR	FSCM	MFGR P N	QTY
1	BRACKET, TUBE MTG	WAVETEK	23338	B420-338	1
2	BEZEL TUBE	WAVETEK	23338	B 420-334	1
3	TUBE HOLDER	WAVETEK	23338	C 420-338	1
4	YOKE	WAVETEK	23338	B 420-503	1
5	GRADICULE, SWEEP	WAVETEK	23338	C 420-335	1
6	GRADICULE, IMPEDANCE	WAVETEK	23338	C 420-341	1
7	LAMP HOUSING	WAVETEK	23338	B 420-330	2
8	LAMP HOUSING	WAVETEK	23338	B 420-337	2
9	POLOROID SCREEN	WAVETEK	23338	B 420-343	1
10					
11					
12					
13	LAMP	MURA	32559	L28/40	4
14	CRT TUBE 5"	THOMAS	01852	SM-10P33M	1
15	PIN 3/32 DIA. x 1/4 LONG	CEM	00287	3/32 x 1/4 MCK	2
16	TAPE, POLYSTER (SILVER)	SCOTCH-3M	26666	350	50"
17	AMP PIN FEMALE	AMP	00779	60598-8	12
18	END BUMPER	ROYAL IND'L	93333	LC7375	4
19	WASHER NYLON	AMATOM	06540	2264-N-385	4
20	NUT 3/8-32 NEF	COML			4
21	LOCK WASHER 3/8	COML			4
22	SOLDER LUG #4	H.H SMITH	83330	1414-4	1
23	NUT, SELF LOCKING #4-40	SPS	56878	21-FA-440	1
24	.020 DIA. PHOSPHOR BRONZE WIRE	COML			1.5"

7. COVER EDGES WITH CONTINUOUS WRAP OF (ITEM 16) POLYSTER TAPE. OVERLAP ENDS.
1. INSTALL PINS, (ITEM 15) THRU BOTH GRADICULES.

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN ADKINS	DATE 9-4-79	WAVETEK SAN DIEGO • CALIFORNIA
MATERIAL	PROJ ENGR	RELEASE APPROV	TITLE ASSEMBLY CATHODE RAY TUBE (2A5) RECEIVER
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ± 1° XX ± .030	DO NOT SCALE DWG	MODEL NO 420
	SCALE FULL		DWG NO D420-042 REV
			CODE IDENT 23338 SHEET 1 OF 1

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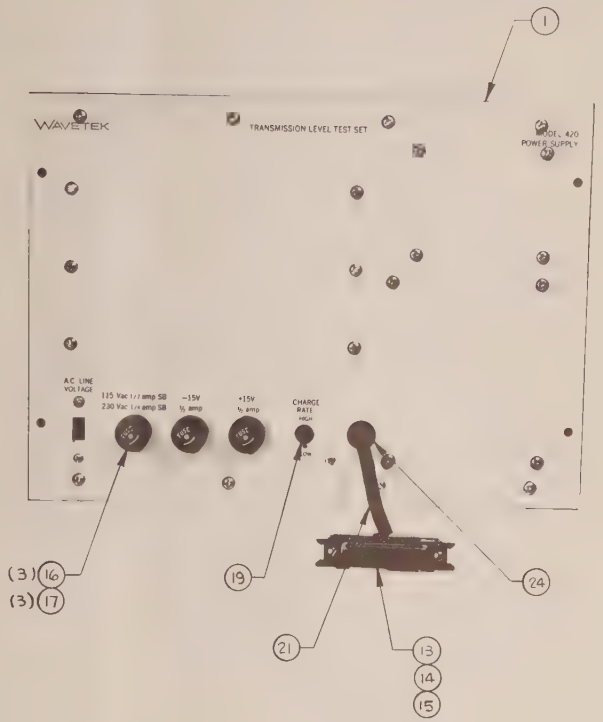
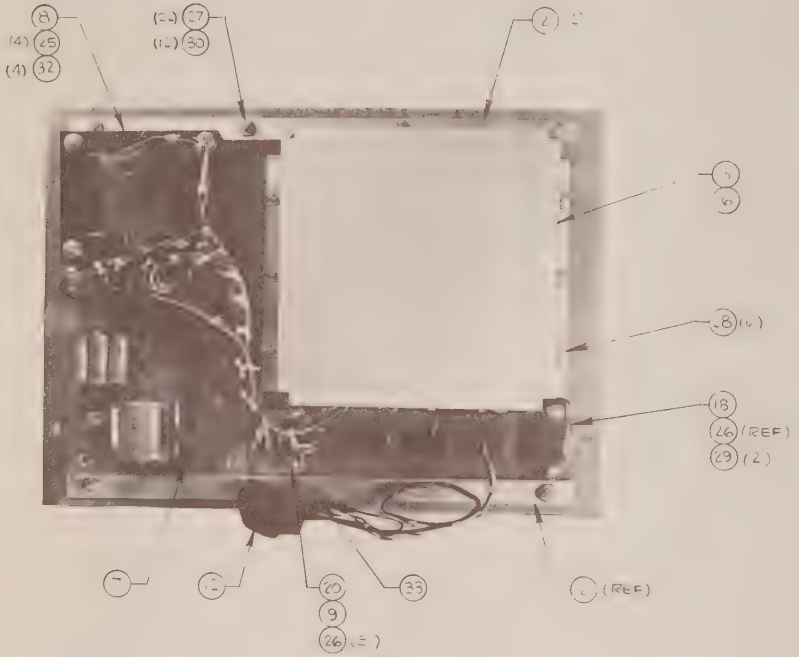
REV	E.N.	BY	DATE	APP
B	4987	P.R.	1/19/78	





NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B. FREEDMAN	DATE 5-30-73	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL —	PROJECTION		TITLE ASSEMBLY, POWER SUPPLY (RECEIVER)
FINISH WAVETEK PROCESS —	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX .010 ANGLES ±1 .XX .030		MODEL NO 420
	DO NOT SCALE DWG		DWG NO D420-003 REV B
	SCALE NONE		CODE IDENT 23338 SHEET 1 OF 2

BRUNING 40 520 15821

D420-003B

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REV	ECN	BY	DATE	APP

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
1	FRONT PANEL	WAVETEK	23338	C420-304	1
2	SUPPORT ANGLE	WAVETEK	23338	B420-347	2
3	BATTERY HOLDER	WAVETEK	23338	C420-324	1
4					
5					
6	BATTERY ASSY	WAVETEK	23338	C420-005	1
7	BATTERY CHARGER BD	WAVETEK	23338	D420-021	1
8	TRANSFORMER	WAVETEK	23338	B420-527	1
9					
10					
11					
12	A.C. RECPTACLE	SWITCHCRAFT	82389	EAC-301	1
13	CONNECTOR	CANNON	31746	DBC-25S	1
14	JUNCTION SHELL	CANNON	31746	DB51212-1	1
15	END DISC LATCH	CANNON	31746	D110278	1
16	FUSE HOLDER	LITTLEFUSE	75915	345001	3
17	FUSE, 1/2 AMB SLO BLO	LITTLEFUSE	75915	313.500	3
18	SWITCH 115/230	SWITCHCRAFT	82389	46256LF	1
19	SWITCH SPST	C&K	09353	7101-PDCN	1
20	TRANSISTOR TIP 30	T.I.	01295	TIP-30	1
21	CABLE, 12 CONDUCTOR	BELDEN	16428	B457-100	22"
22	GUARD, SOLDER	SWITCHCRAFT	82389	46256-LF-SG	1
23					
24	GROMMET	H.H. SMITH	83330	91117	1
25	SPACER	H.H. SMITH	83330	8713	4
26					
27					
28	SPEED NUT	TINNERMAN	78553	C880-632	6
29	NUT, SELF LOCKING #4	SPS	56878	21-FA-440	2

PARTS LIST

LINE NO.	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
30	NUT, SELF LOCKING #6	SPS	56878	21-FA-632	12
31					
32	SCREW, #6-32 X 2" LONG	COML			4
33	SOLDER LUG	H.H. SMITH	83330	1414 4	1

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES
MATERIAL
FINISH WAVETEK PROCESS
DRAWN B. REDMAN DATE 5/30/78
PROJ ENGR
RELEASE APPROV
TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ±1° XX ± .030
DO NOT SCALE DWG
SCALE

WAVETEK SAN DIEGO, CALIFORNIA

TITLE: ASSEMBLY, POWER SUPPLY (RECEIVER)

MODEL NO 420
DWG NO B420-003
REV B
CODE IDENT 23338
SHEET 2 OF 2

B420-003 B

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REV	ECN	BY	DATE	APP

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
1	CAPACITOR CERAMIC DISC .005μF	CRL	71590	CK502	2
2	CERAMIC DISC 220PF	CRL	71590	DD221	2
3	TANTALUM .47μF	SPRAGUE	56289	150D474X9050B2	1
4	TANTALUM 10μF	SPRAGUE	56289	150D106X902B2	1
5	ELECTROLYTIC 50V 50μF	SPRAGUE	56289	500D506G05DD7	3
6	ELECTROLYTIC 75V 250μF	SPRAGUE	56289	39D257G075JE4	1
7					
8					
9	DIODE 6.4V ZENER	DICKSON	12954	IN4581	3
10	DIODE 100V G.P. SILCON	MOTOROLA	04713	IN4002	7
11	DIODE 100V G.P. SILCON	FAIRCHILD	33888	FD6666	10
12	DIODE 6.4V ZENER	DICKSON	12954	IN4581 (-84)	1
13					
14	INTEGRATED CIRCUITS				
15	INTEGRATED CIRCUITS μA709	FAIRCHILD	33888	μA709C (-14)	2
16	INTEGRATED CIRCUITS μA709	FAIRCHILD	33888	μ A709C (-44)	1
17					
18					
19	TRANSISTOR 2N2219A	FAIRCHILD	33888	2N2219A	1
20	TRANSISTOR 2N3642	FAIRCHILD	33888	2N3642	1
21	TRANSISTOR 2N3643	FAIRCHILD	33888	2N3643	2
22					
23	RESISTOR 1W 5% 470Ω	STACKPOLE	29604	RC32GF471J	1
24	METAL FILM, 1/8W, 1%, 15Ω	CORNING	16299	RN55D	1
25	METAL FILM, 1/8W, 1%, 499Ω	CORNING	16299	RN55D	1
26	METAL FILM, 1/8W, 1%, 1K	CORNING	16299	RN55D	4
27	METAL FILM, 1/8W, 1%, 1.5K	CORNING	16299	RN55D	1
28	METAL FILM, 1/8W, 1%, 3.32K	CORNING	16299	RN55D	1
29	METAL FILM, 1/8W, 1%, 7.5K	CORNING	16299	RN55D	1

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
30	METAL FILM, 1/8W, 1%, 10K	CORNING	16299	RN55D	2
31	METAL FILM, 1/8W, 1%, 10.5K	CORNING	16299	RN55D	1
32	METAL FILM, 1/8W, 1%, 19.6K	CORNING	16299	RN55D	1
33	METAL FILM, 1/8W, 1%, 49.9K	CORNING	16299	RN55D	2
34	METAL FILM, 1/8W, 1%, 69.8K	CORNING	16299	RN55D	1
35	METAL FILM, 1/8W, 1%, 100K	CORNING	16299	RN55D	1
36	METAL FILM, 1/8W, 1%, 301K	CORNING	16299	RN55D	1
37	POTENTIOMETER 100Ω	BECKMAN	80740	91AR100Ω	1
38	POTENTIOMETER 10K	BECKMAN	80740	91AR10K	1
39	AMP PINS	AMP	00779	61182-2	28
40	CLAMP	SEASTROM	86928	4511-100-68-2C	1
41	TINNERMAN CLIPS	TINNERMAN	78553	CB80-632	2
42	TERMINALS	USECO	88245	20008-1	4
43	SWAGE STANDOFFS	USECO	88245	1530B-1/4-11	4
44	TRANSISTOR PAD	MILTON ROSS	07047	10123N	4
45	RESISTANCE WIRE	WILBER DRIVER	72005	830AWG (30 PER FOOT)	AR
46					
47					
48	CIRCUIT BOARD	WAVETEK	23338	420-110B	1
49					
50					
51					
52					
53					
54					
55					
56					
57					

LINE ITEM REFERENCE LIST

REF DES	P/L LINE	REF DES	P/L LINE	REF DES	P/L LINE
C1	5	IC1	14		
C2	5	IC2	15		
C3	6	IC3	13		
C4	1				
C5	2				
C6	3	Q1	17		
C7	4	Q2	18		
C8	2	Q3	19		
C9	1	Q4	20		
C10	5				
R1	10	R1	12		
CR2	10	R2	13		
CR3	10	R4	14		
CR4	10	R5	15		
CR5	10	R6	16		
CR6	10	R7	22		
CR7	9	R8	23		
CR8	11	R9	24		
CR9	11	R10	25		
CR10	10	R11	26		
CR11	11	R12	27		
CR12	11	R13	28		
CR13	11	R14	29		
CR14	11	R15	30		
CR15	11	R16	31		
CR16	11	R17	32		
CR17	9	R18	33		
CR18	12	R19	34		
CR19	13	R20	35		
CR20	9	R21	37		
CR21	11	R22	38		
		R23	39		
		R24	41		
		R25	42		

NOTE. UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN E. REDMAN	DATE 5/5/78	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	PROJECT ENGR	7/21/78	TITLE ASSEMBLY BATTERY CHARGER BD (RECEIVER)
FINISH WAVETEK PROCESS	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ±.010 ANGLES ±1° XX ±.030		
	DO NOT SCALE DWG		MODEL NO. 420 / DWG NO. B420-021 / REV F
	SCALE —		CODE IDENT 23338 / SHEET 2 OF 2

B420-021 F

BRUNING 40-320 19821

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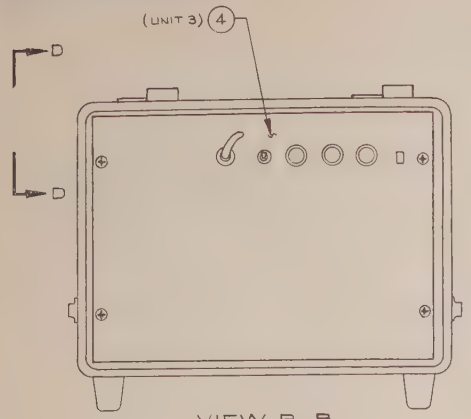
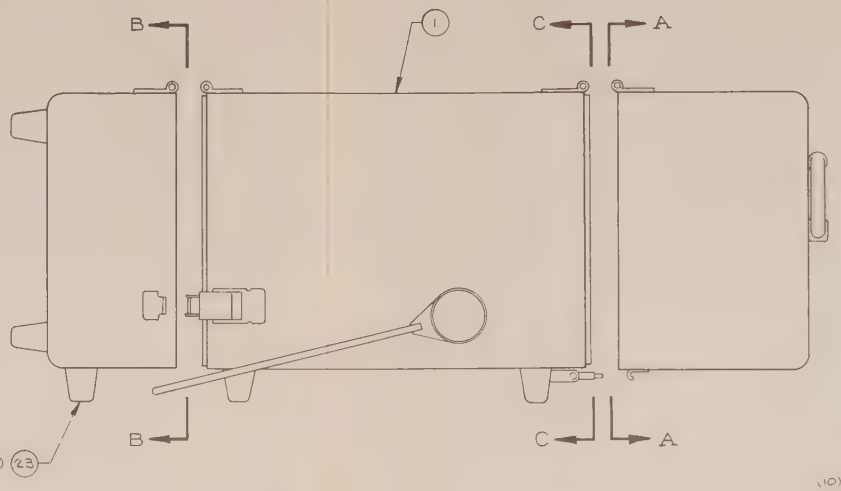
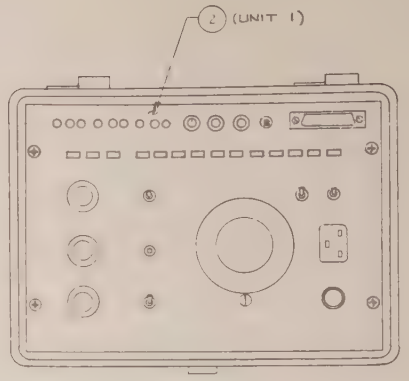
REV	ECN	BY	DATE	APP



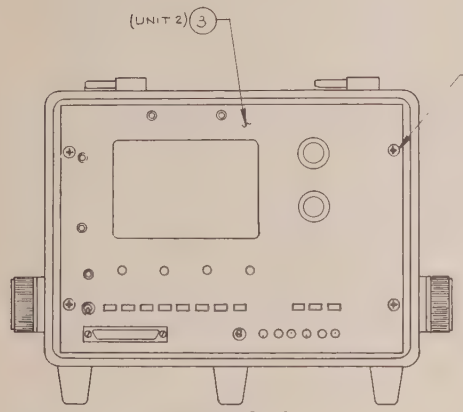
VIEW B-B

VIEW D-D

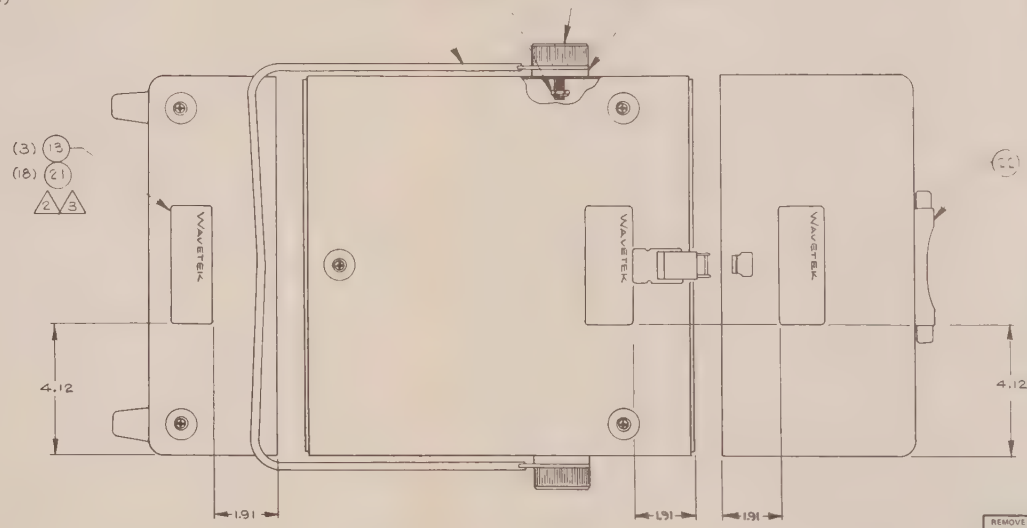




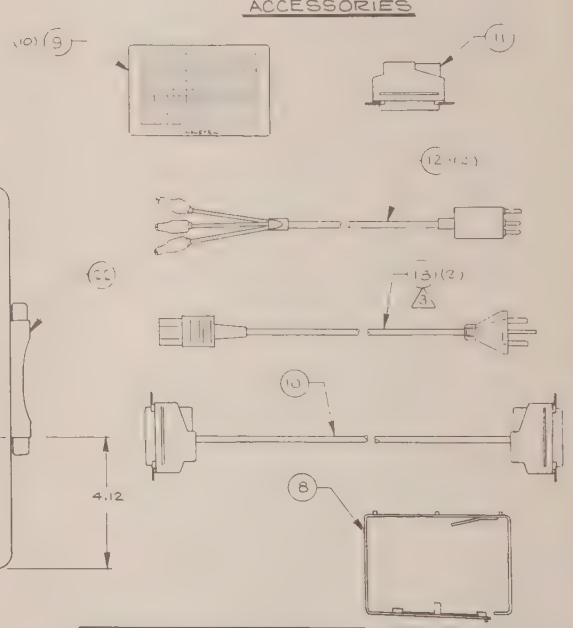
VIEW A-A



VIEW C-C



ACCESSORIES



ACCESSORIES
(NOT SHOWN)

(14) ACCESSORY BAG (1)

(19) MARKING PENCIL (1)

3. ALTERNATE SOURCE OF SUPPLY FOR 6 FOOT POWER CORD.
ELECTRICORD (GARDENA, CALIF)
PART NUMBER: C2107-006-6Y

2. METAL STAMP MODEL NUMBER (420-S-438) & SERIAL NUMBER ON I.D. PLATES.

1. MATCH DRILL (.093 (3/32) DIA HOLE) THRU I.D. PLATE & CASE. INSTALL POP-RIVET (18 PLACES).

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B. REDMAN	DATE 4-22-74	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	PROJ ENGR	6/3/74	TITLE ASSEMBLY, TRANSMISSION LEVEL TEST SET
FINISH WAVETEK PROCESS	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ±1° XX ± .030		
	DO NOT SCALE DWG		MODEL NO 420-S-438 DWG NO D398-000 REV
	SCALE 1/2		CODE IDENT 23338 SHEET 1 OF 2

D398-000

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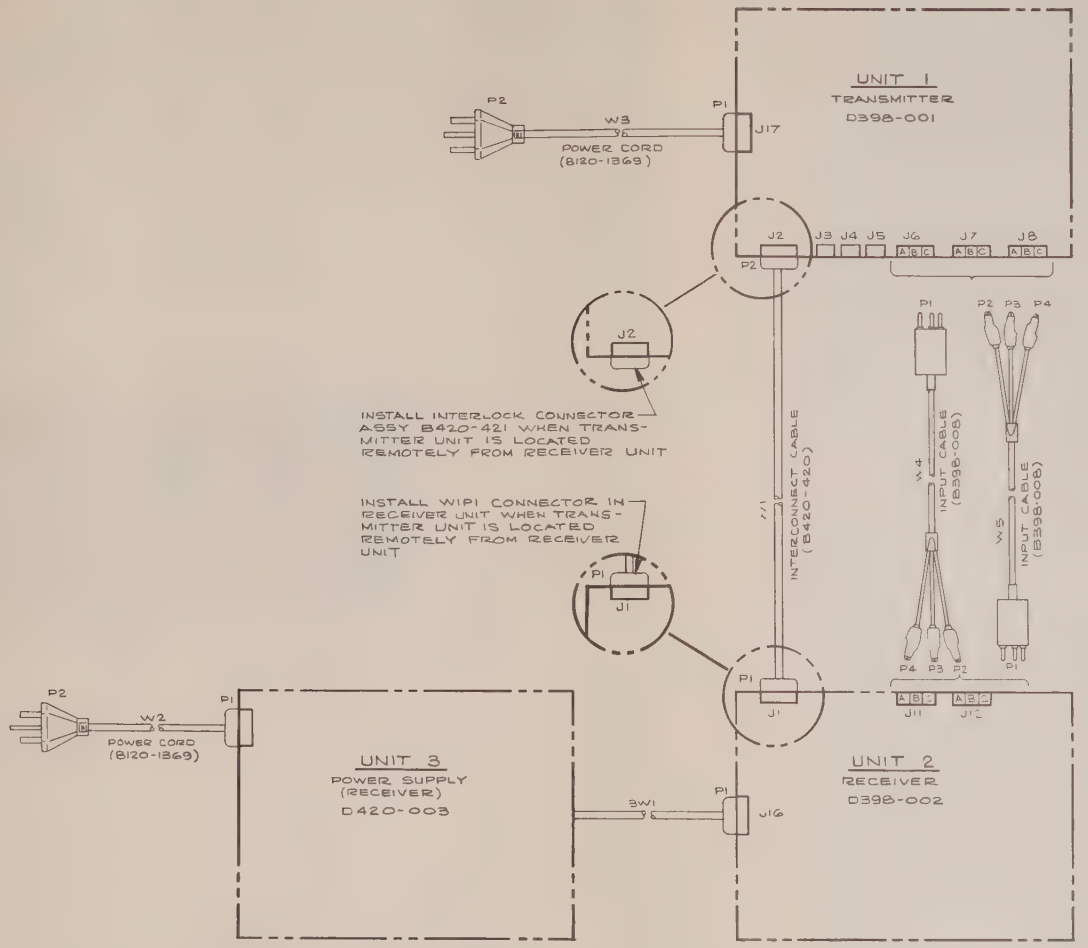
REV	ECN	BY	DATE	APP



UNIT 1 SUBASSEMBLIES
- 1A1 - TRANSMITTER MAIN BD
- 1A2 - ATTENUATOR BD
- 1A3 - SWEEP GENERATOR / Z COMPARE BD
- 1A4 - BATTERY CHARGER BD
- 1A5 - BATTERY ASSY
- 1A6 - SIGNAL FREQUENCY SUPPRESSION BD

INPUT CABLES W4 & W5
- P2 - RED LEAD TO P1-C (GROUND)
- P3 - WHITE LEAD TO P1-B
- P4 - BLACK LEAD TO P1-A

UNIT 3 SUBASSEMBLIES
- 3A1 - BATTERY CHARGER BD
- 3A2 - BATTERY ASSY

UNIT 2 SUBASSEMBLIES
- 2A1 - RECEIVER MAIN BD
- 2A2 - ATTENUATOR BD
- 2A3 - HIGH VOLTAGE/Z COMPARE BD
- 2A4 - INTERFACE BD
- 2A5 - CATHODE RAY TUBE ASSY

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B.T.ROMAN	DATE 6 7 74	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	PROJ ENGR		TITLE SCHEMATIC DIAGRAM, CHASSIS (INTERCONNECT)
	RELEASE APPROV		
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ±1° XX ± .030		
	DO NOT SCALE DWG	MODEL NO 420-S-438	DWG NO D398-200 REV
	SCALE	CODE IDENT 23338	SHEET 1 OF 3

D398-200

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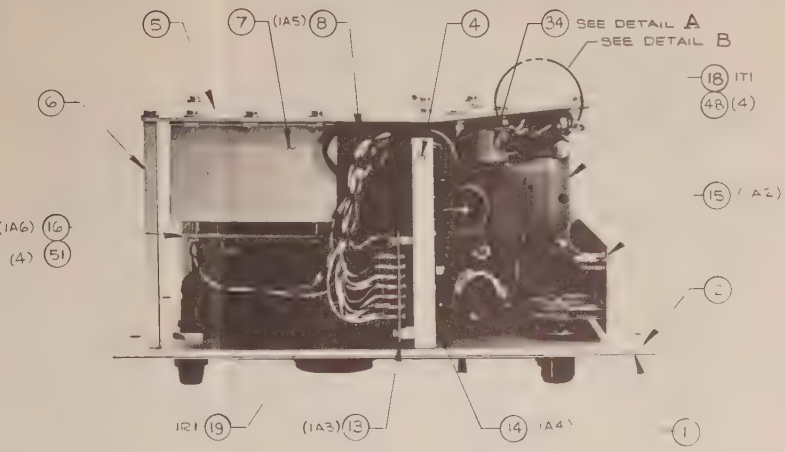

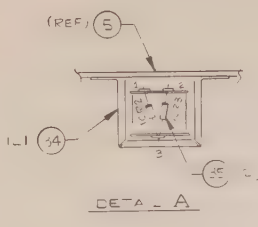

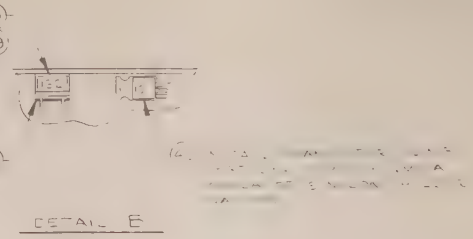

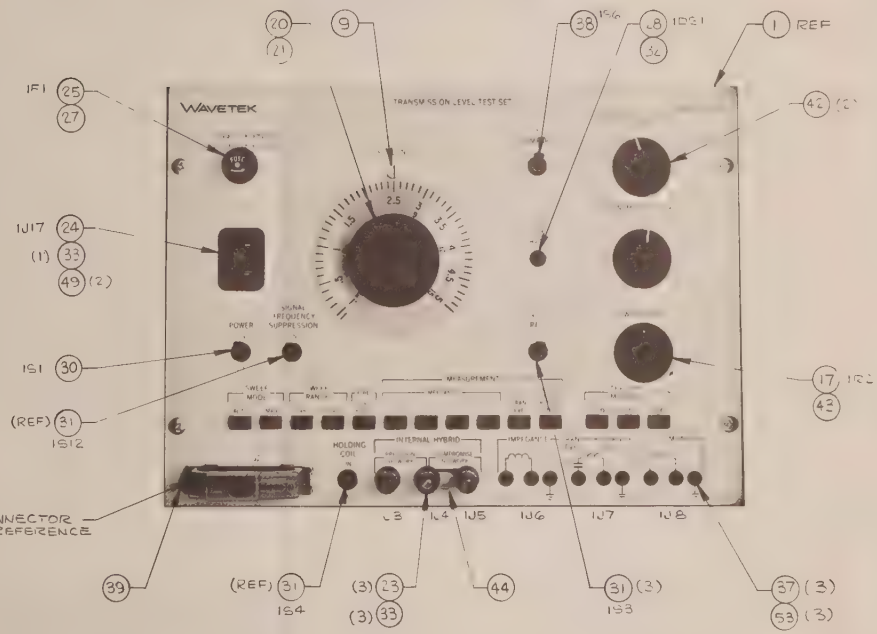

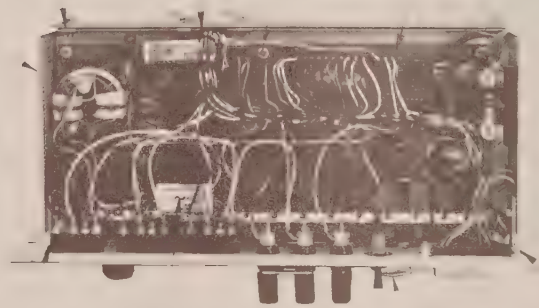

1. ALL LOCK WASHERS MUST BE SPRING(SPLIT) LOCK TYPE.

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN E. REDMAN	DATE 6/13/14	WAVETEK
MATERIAL			TITLE ASSEMBLY, TRANSMITTER (UNIT 1)
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX .010 ANGLES 1°		
	DO NOT SCALE DWG		MODEL NO 420-S-438 DWG NO D598-001 REV
			CODE IDENT 23338 SHEET 1 OF 2

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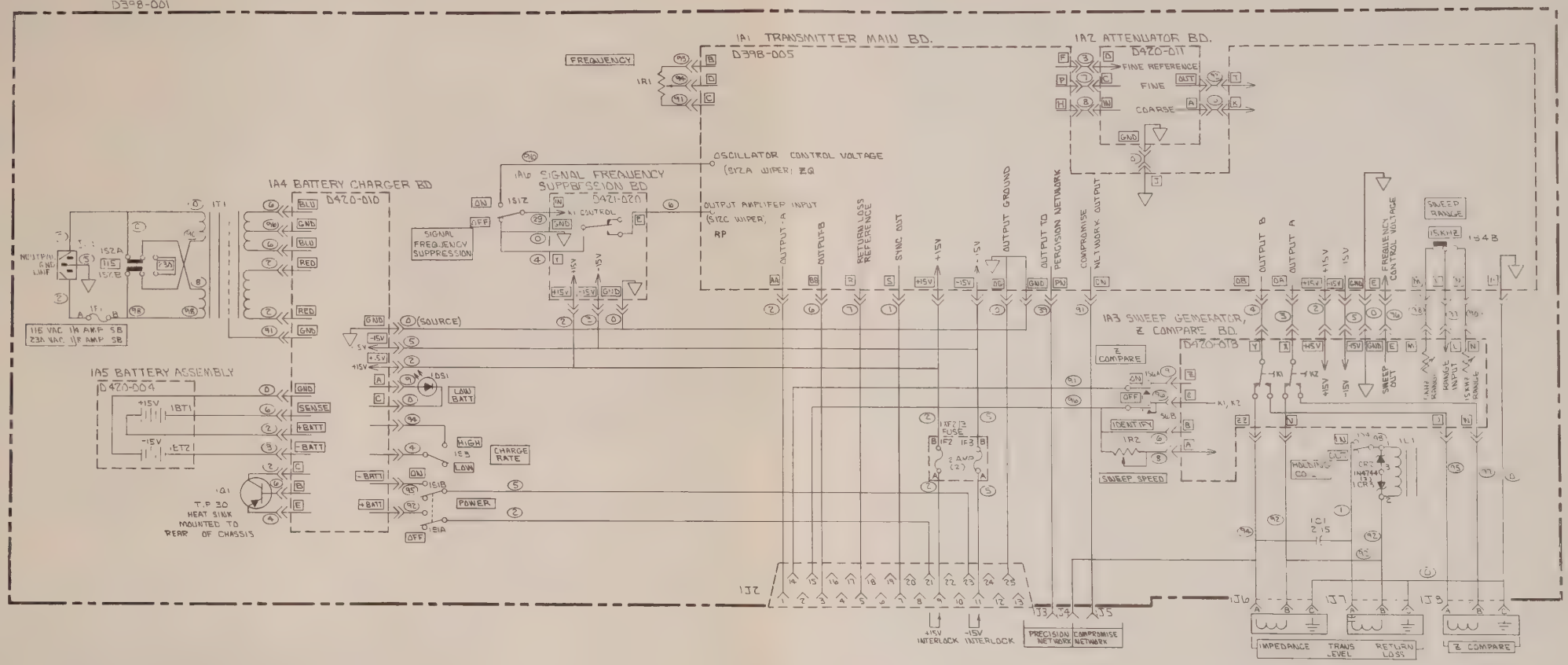
REV	ECN	BY	DATE	APP

UNIT 1 TRANSMITTER D398-001



NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN ADKINS	DATE 5-30-74	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	PROJ ENGR		TITLE SCHEMATIC DIAGRAM CHASSIS (UNIT 1) TRANSMITTER
FINISH WAVETEK PROCESS	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 XX ± .030 ANGLES ± 1°		
	DO NOT SCALE DWG		MODEL NO 420-S-438 DWG NO D398-200 REV
	SCALE		CODE IDENT 23338 SHEET 2 OF 3

D398-200

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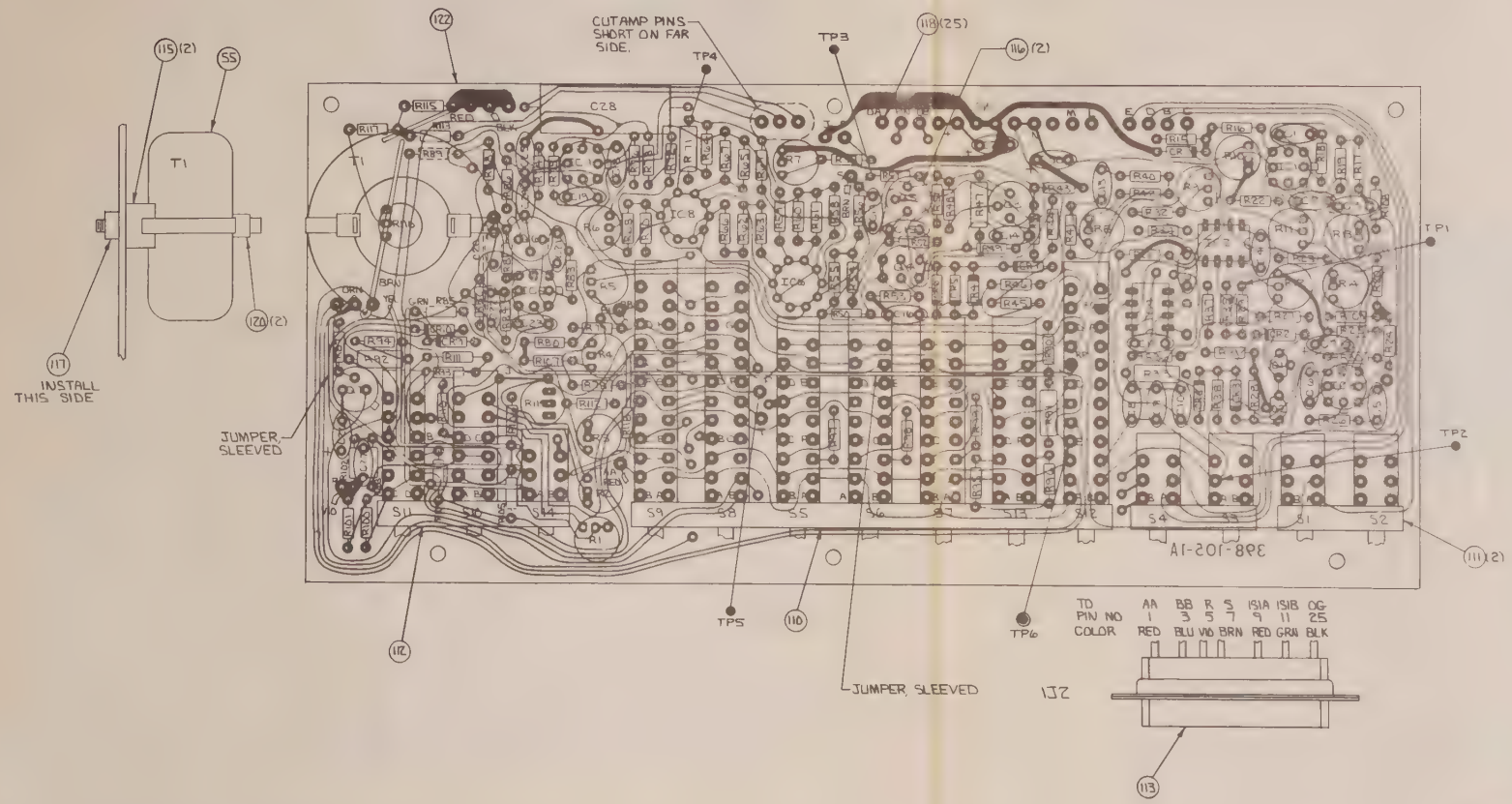
REV	ECN	BY	DATE	APP
A	ARTWORK CHANGE ONLY NO COMPONENT CHANGE	BA	6-14-74	

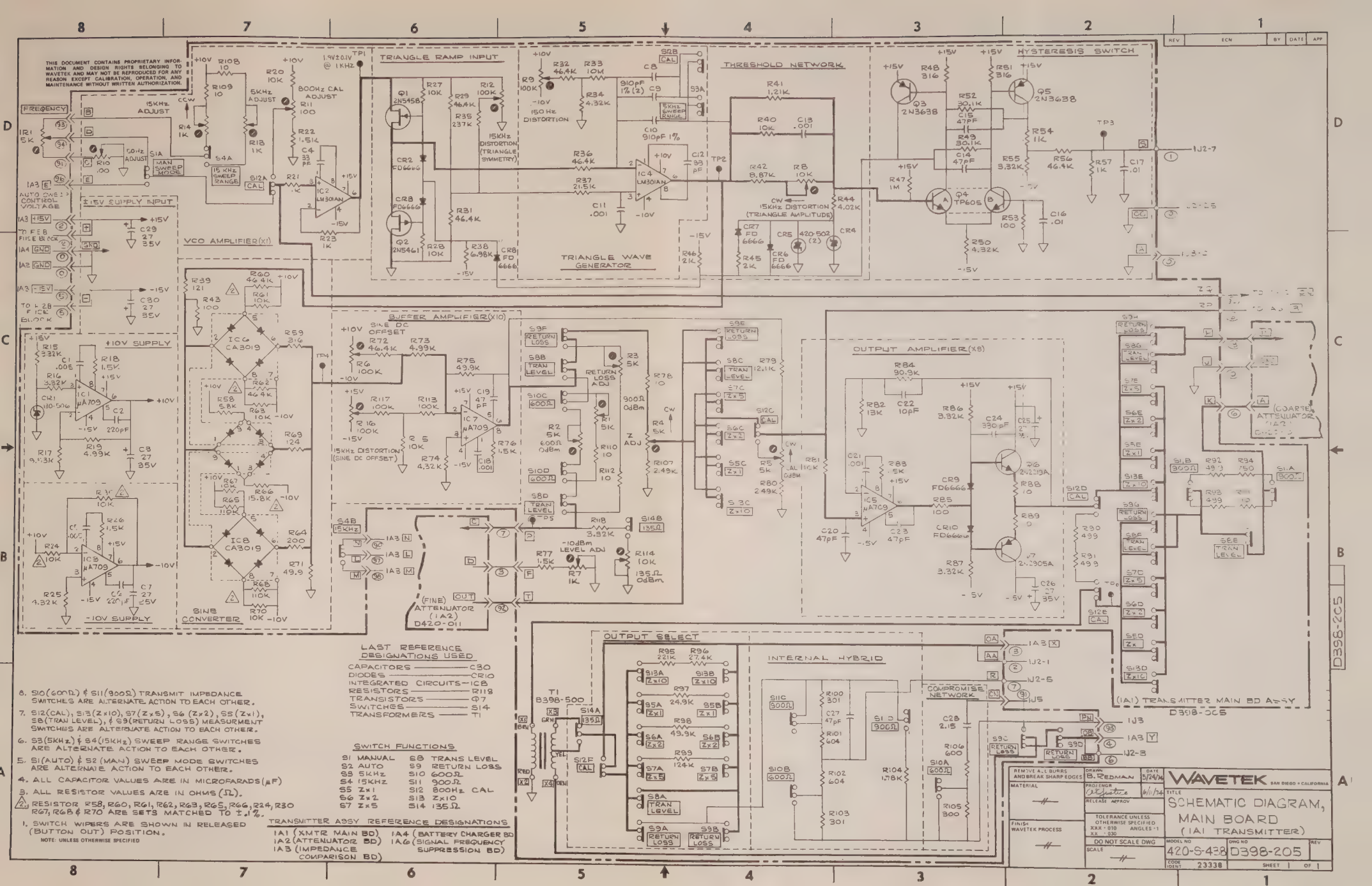


1. 10K MATCHED RESISTORS (ITEM 103) ARE TO BE INSTALLED AS FOLLOWS: R24 & R30; R61 & R103; R67 & R70.

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN ADKINS	DATE 6-14-74	WAVETEK SAN DIEGO • CALIFORNIA
MATERIAL /	PROJ ENGR [illegible]		TITLE ASSEMBLY MAIN BOARD (1A1) TRANSMITTER
FINISH WAVETEK PROCESS /	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX .010 ANGLES ±1 XX .030		MODEL NO 420-S-438 DWG NO D398-005 REV A
	DO NOT SCALE DWG SCALE 2/1		CODE IDENT 23338 SHEET 1 OF 3

D398-005 A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TRIANGLE RAMP INPUT
THRESHOLD NETWORK
HYSTERESIS SWITCH
TRIANGLE WAVE GENERATOR
VCO AMPLIFIER(x1)
BUFFER AMPLIFIER(x10)
OUTPUT AMPLIFIER(x8)
±15V SUPPLY INPUT
+10V SUPPLY
-10V SUPPLY
SINE CONVERTER
OUTPUT SELECT
INTERNAL HYBRID
COMPROMISE NETWORK
FREQUENCY
15KHz ADJUST
5KHz ADJUST
800Hz CAL ADJUST
50Hz ADJUST
MAN SWEEP MODE
15 KHz SWEEP RANGE
5KHz SWEEP RANGE
AUTO SWEEP CONTROL VOLTAGE
1.9V±0.1V @ 1KHz
-10V 150 Hz DISTORTION
15KHz DISTORTION (TRIANGLE SYMMETRY)
CW 15KHz DISTORTION (TRIANGLE AMPLITUDE)
15KHz DISTORTION (SINE DC OFFSET)
SINE DC OFFSET
RETURN LOSS ADJ
Z ADJ
-10dBm LEVEL ADJ
(FINE) ATTENUATOR (1A2) D420-011
(COARSE) ATTENUATOR (1A2)
(1A1) TRANSMITTER MAIN BD ASSY D398-205
TO FREQ BLOCK
TO FREQ FINE BLOCK
TO A2J3
TO A2J5
1A2J7
1A2J5
1A2J3
1A3J3
1A3J2-1
1A3J2-5
1A3J2-3
1A3J5
T1 B398-500
LAST REFERENCE DESIGNATIONS USED
CAPACITORS — C30
DIODES — CR10
INTEGRATED CIRCUITS — IC8
RESISTORS — R118
TRANSISTORS — Q7
SWITCHES — S14
TRANSFORMERS — T1
SWITCH FUNCTIONS
S1 MANUAL S8 TRANS LEVEL
S2 AUTO S9 RETURN LOSS
S3 5KHz S10 600Ω
S4 15KHz S11 900Ω
S5 Zx1 S12 800Hz CAL
S6 Zx2 S13 Zx10
S7 Zx5 S14 135Ω
TRANSMITTER ASSY REFERENCE DESIGNATIONS
1A1 (XMTR MAIN BD) 1A4 (BATTERY CHARGER BD)
1A2 (ATTENUATOR BD) 1A6 (SIGNAL FREQUENCY SUPPRESSION BD)
1A3 (IMPEDANCE COMPARISON BD)
6. S10(600Ω) & S11(900Ω) TRANSMIT IMPEDANCE SWITCHES ARE ALTERNATE ACTION TO EACH OTHER.
7. S12(CAL), S13(Zx10), S7(Zx5), S6(Zx2), S5(Zx1), S8(TRAN LEVEL), & S9(RETURN LOSS) MEASUREMENT SWITCHES ARE ALTERNATE ACTION TO EACH OTHER.
6. S3(5KHz) & S4(15KHz) SWEEP RANGE SWITCHES ARE ALTERNATE ACTION TO EACH OTHER.
5. S1(AUTO) & S2(MAN) SWEEP MODE SWITCHES ARE ALTERNATE ACTION TO EACH OTHER.
4. ALL CAPACITOR VALUES ARE IN MICROFARADS(μF)
3. ALL RESISTOR VALUES ARE IN OHMS (Ω).
2. RESISTOR R58, R60, R61, R62, R63, R65, R66, R24, R30 R67, R68 & R70 ARE SETS MATCHED TO ±1%.
1. SWITCH WIPERS ARE SHOWN IN RELEASED (BUTTON OUT) POSITION.
NOTE: UNLESS OTHERWISE SPECIFIED
REMOVE ALL BURRS AND BREAK SHARP EDGES
MATERIAL
FINISH WAVETEK PROCESS
DRAWN B. TEDMAN 5/24/74
PROJ ENGR 6/11/74
RELEASE APPROV
TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ±.010 ANGLES ±1 XX ±.030
DO NOT SCALE DWG
SCALE
WAVETEK SAN DIEGO, CALIFORNIA
TITLE SCHEMATIC DIAGRAM, MAIN BOARD (1A1 TRANSMITTER)
MODEL NO 420-S-438
DWG NO D398-205
REV
CODE IDENT 23338
SHEET 1 OF 1

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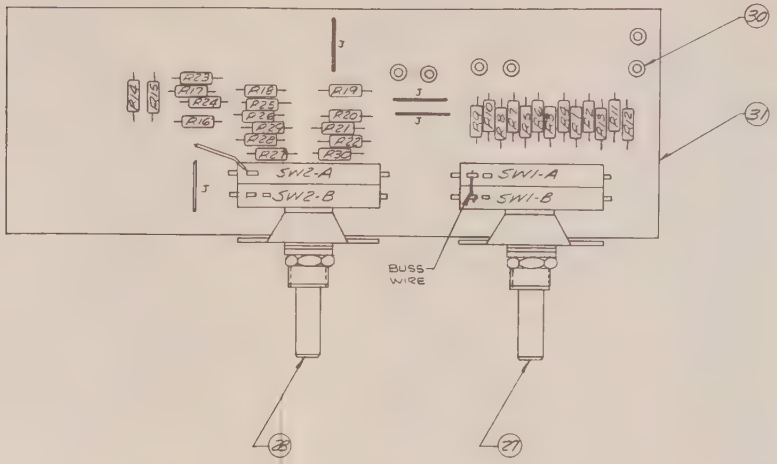
REV	ECN	BY	DATE	APP



NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN M BOEHLKE	DATE 5-11-93	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	PROVENCE		TITLE ASSEMBLY ATTENUATOR (TRANSMITTER)
	RELEASE APPROV		
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ±.010 XX ±.030 ANGLES ±1°		
	DO NOT SCALE DWG	MODEL NO. 420	DWG NO. D420-011 REV F
	SCALE 2:1	CODE IDENT 23338	SHEET 1 OF 2

D420-011 E

BRUNING 40-320 15831

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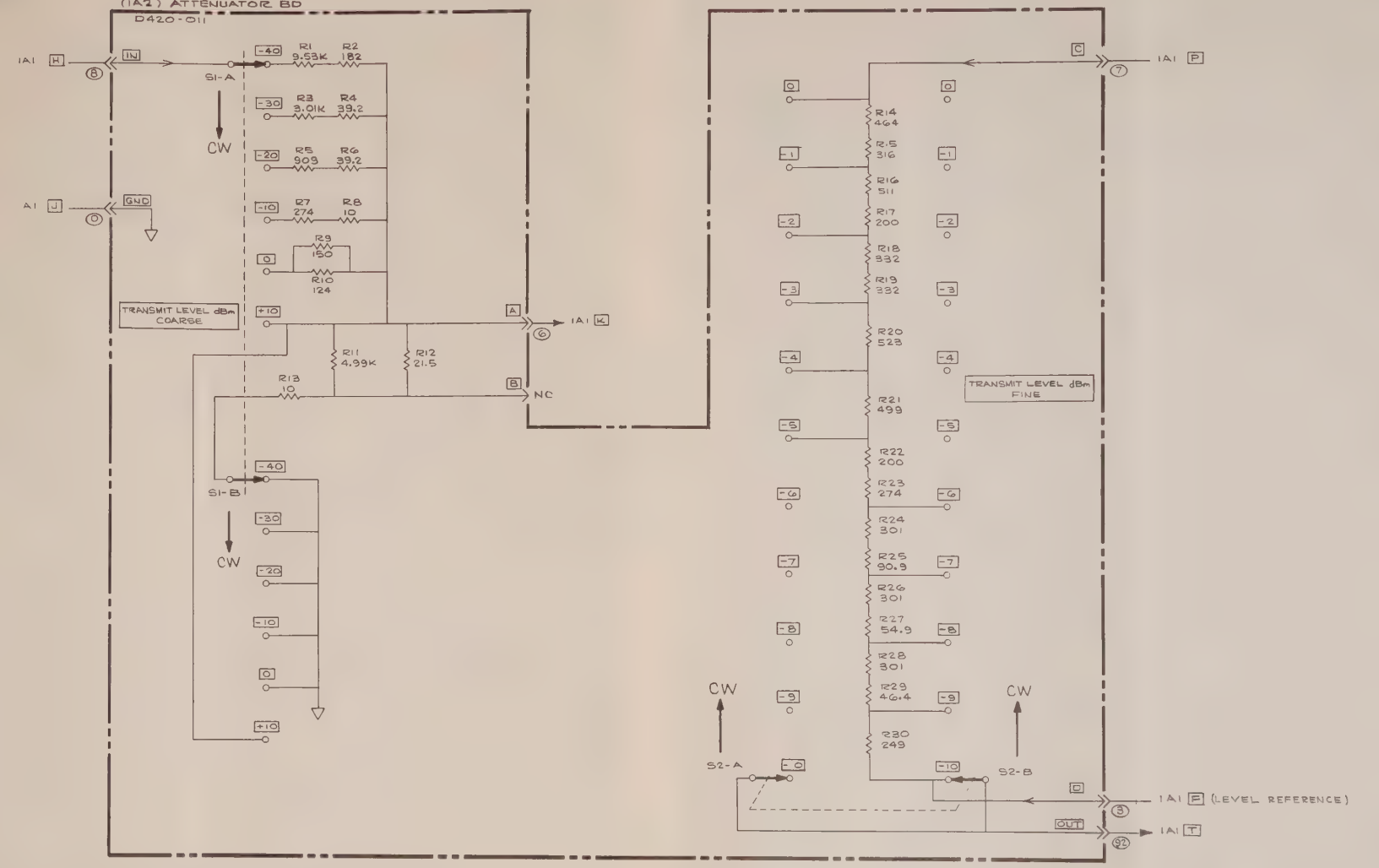
REV	ECN	BY	DATE	APP
A	ECN 949	BA	6-29-84	



LAST REFERENCE DESIGNATIONS USED

RESISTORS —— R30

SWITCHES —— S2

2. ROTARY SWITCHES (S1 & S2) ARE SHOWN FULLY CCW AS VIEWED FROM KNOB END OF SHAFT.
1. ALL RESISTOR VALUES ARE IN OHMS (Ω).

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B. REDMAN	DATE 5-6-76	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	PROJ. ENGR		TITLE SCHEMATIC DIAGRAM, ATTENUATOR BD (1A2) TRANSMITTER
FINISH WAVETEK PROCESS	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ±1° XX ± .030		
	DO NOT SCALE DWG		MODEL NO 420 DWG NO D420-211 REV A
	SCALE		CODE IDENT 23338 SHEET 1 OF 1

D420-211 A

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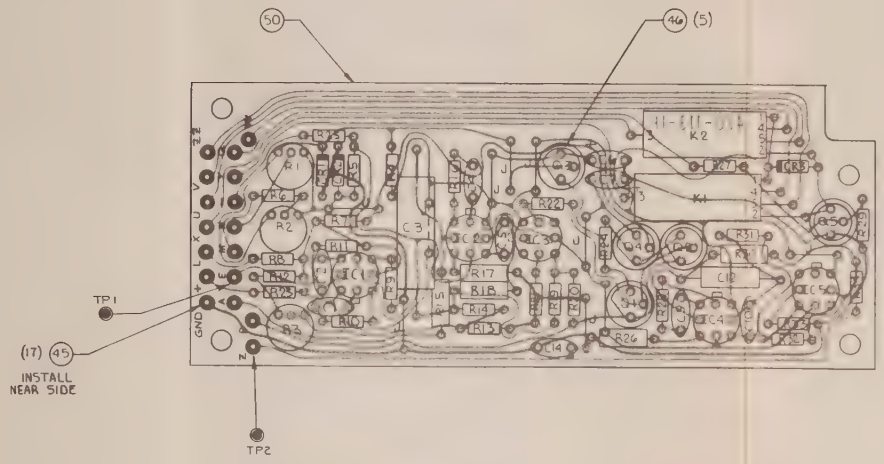
REV	ECN	BY	DATE	APP



NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN BARNETT	DATE 3.15.78	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	ENGR		TITLE ASSEMBLY– SWEEP GENERATOR (1A3) TRANSMITTER
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED .XX ± .01 .XXX ± .005 ANGLES ± 1°		
	DO NOT SCALE DWG	SCALE 2/1	MODEL NO 420-S-438 DWG NO D420-018 REV
			CAGE IDENT 23338 SHEET 1 OF 2

D420-018

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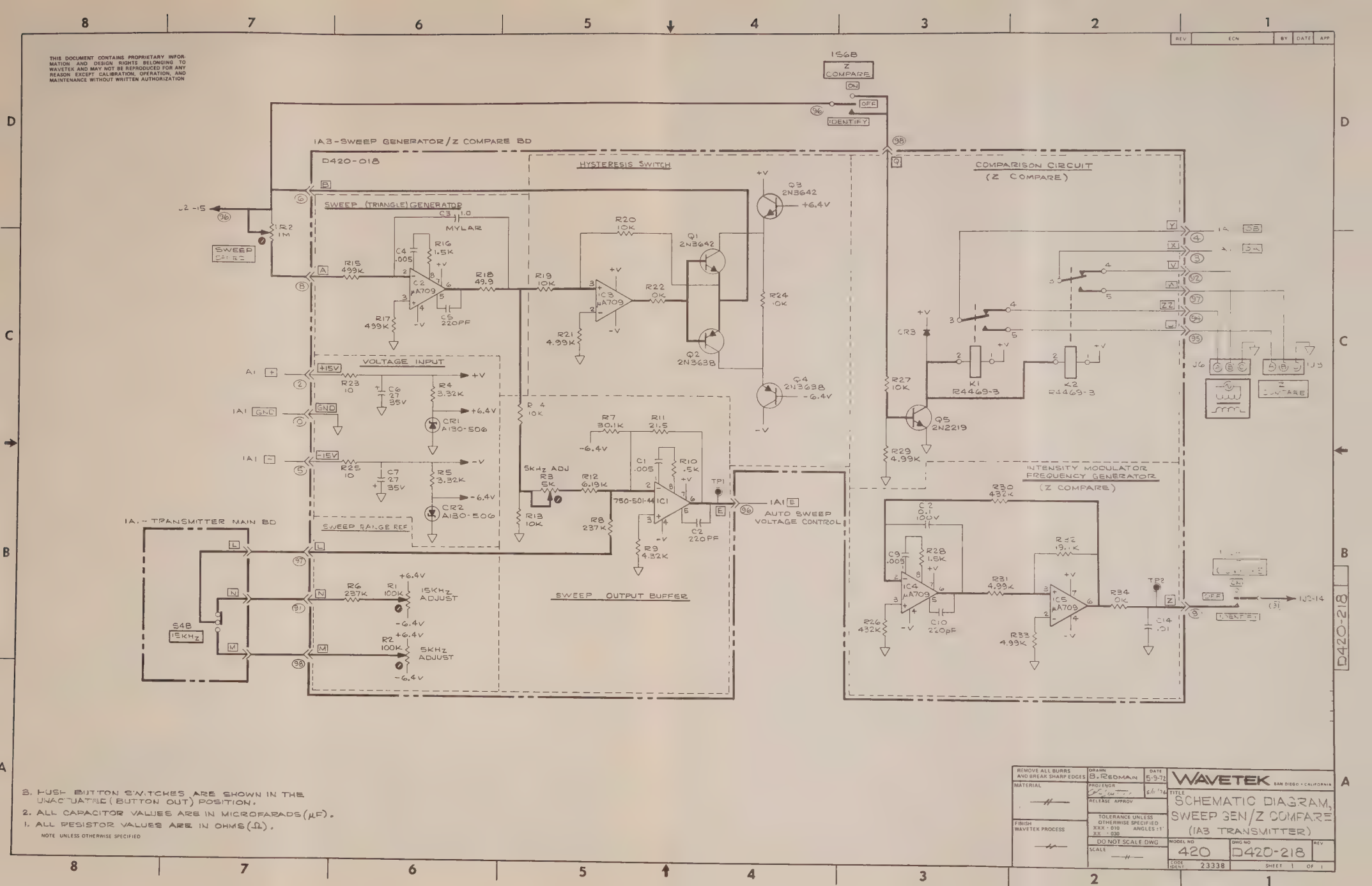
REV	ECN	BY	DATE	APP



3. PUSH BUTTON SWITCHES ARE SHOWN IN THE UNACTUATED (BUTTON OUT) POSITION.
2. ALL CAPACITOR VALUES ARE IN MICROFARADS (µF).
1. ALL RESISTOR VALUES ARE IN OHMS (Ω).

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN G. REDMAN	DATE 5-9-72	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	PROJ ENGR	6/11/76	TITLE SCHEMATIC DIAGRAM, SWEEP GEN/Z COMPARE (1A3 TRANSMITTER)
FINISH WAVETEK PROCESS	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 XX ± .030 ANGLES ±1°		MODEL NO 420
	DO NOT SCALE DWG		DWG NO D420-218 REV
	SCALE		CODE IDENT 23338 SHEET 1 OF 1

D420-218

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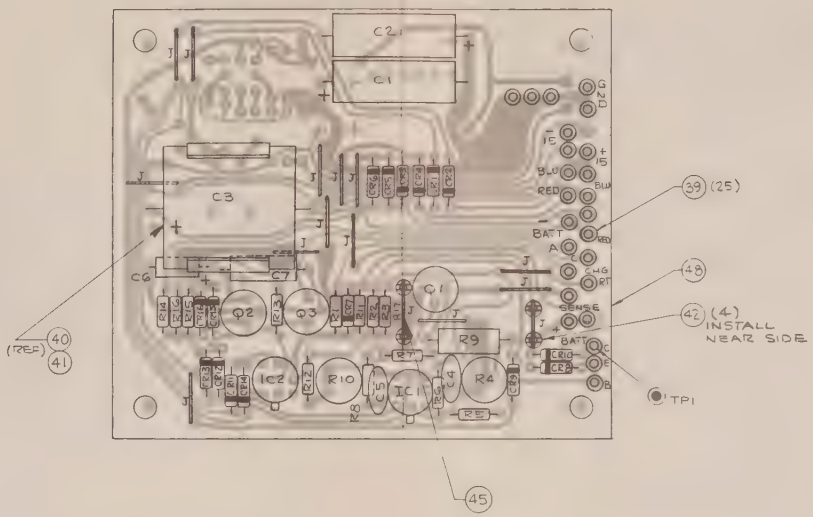
REV	ECN	BY	DATE	APP
C	773	BA	1-6-83	
D	ECN 911	DW	4-4-84	
E	ECN 975	BA	4-1-85	
F	ECN 975.1	BA	4-1-85	



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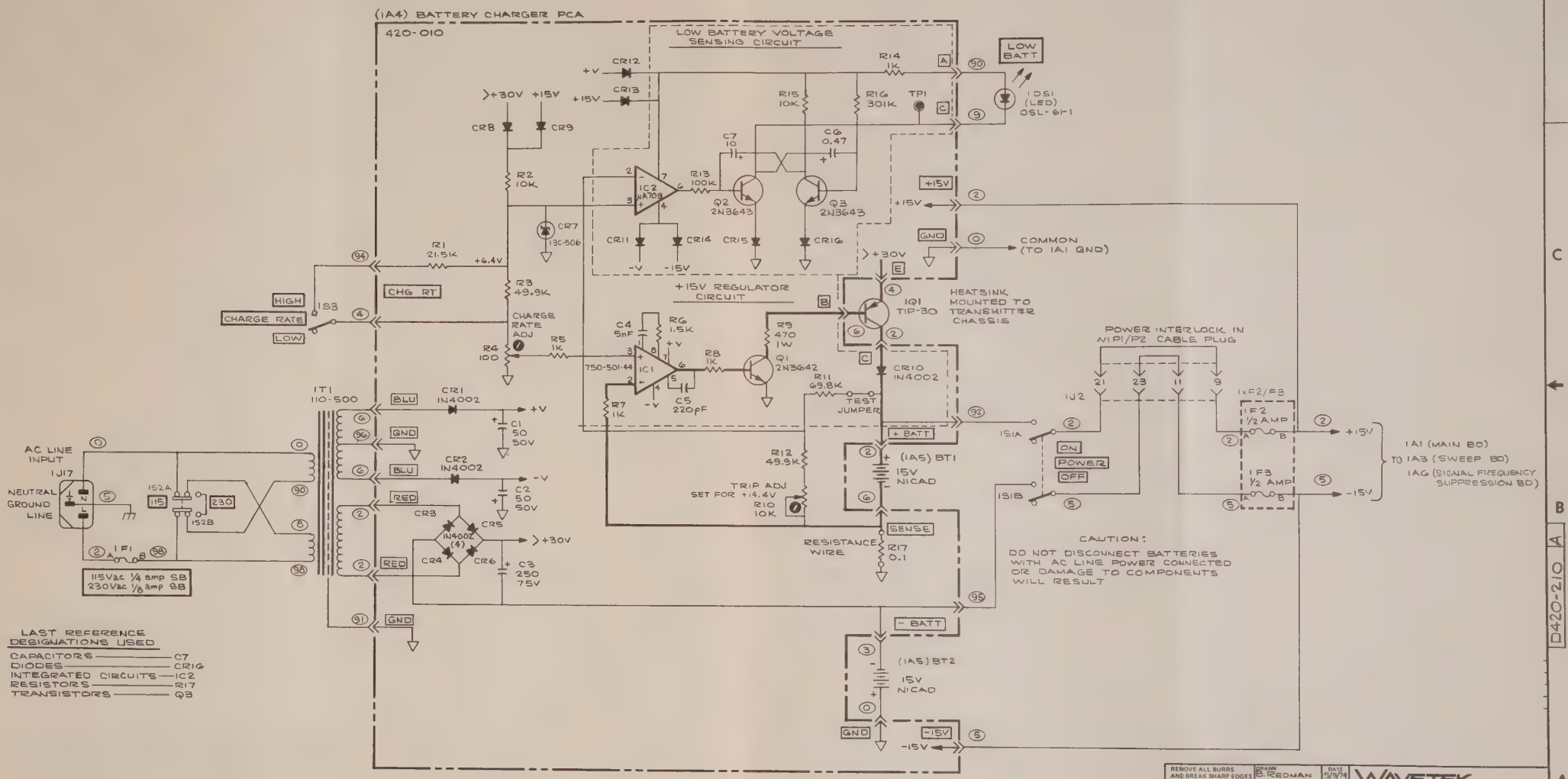
REV	ECN	BY	DATE	APP
A	ECN 949	BA	6/9/81	



LAST REFERENCE DESIGNATIONS USED

CAPACITORS	C7
DIODES	CR16
INTEGRATED CIRCUITS	IC2
RESISTORS	R17
TRANSISTORS	Q3

3. ALL DIODES ARE FD6666.
2. ALL RESISTORS IN OHMS (Ω).
1. ALL CAPACITORS IN MICROFARADS (μF).
NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN C. REDMAN	DATE 5/9/74
MATERIAL —	PROJ ENGR	6/11/74
FINISH WAVETEK PROCESS —	RELEASE APPROV	
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 XX ± .030 ANGLES ±1°	
	DO NOT SCALE DWG	
	SCALE —	

WAVETEK SAN DIEGO, CALIFORNIA

TITLE: SCHEMATIC DIAGRAM, BATTERY CHARGER BD (1A4 TRANSMITTER)

MODEL NO	DWG NO	REV
420	D420-210	A

CODE IDENT 23338 — SHEET 1 OF 1

D420-210 A

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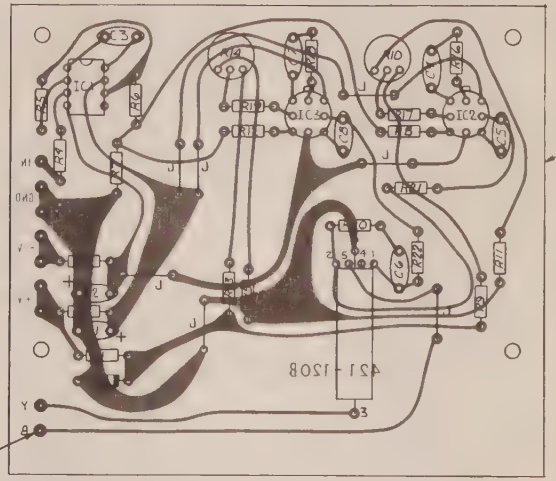
REV	ECN	BY	DATE	APP



NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN BARNETT	DATE 3-20-74	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	PROFING [signature]	4/25/74	TITLE ASSEMBLY- S.F. SUPPRESSION (IAG) TRANSMITTER
FINISH WAVETEK PROCESS	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ± 1 XX ± .030		
	DO NOT SCALE DWG		MODEL NO 421 / DWG NO D421-020 / REV
	SCALE 2/1		CODE IDENT 23338 / SHEET 1 OF 2

D421-020

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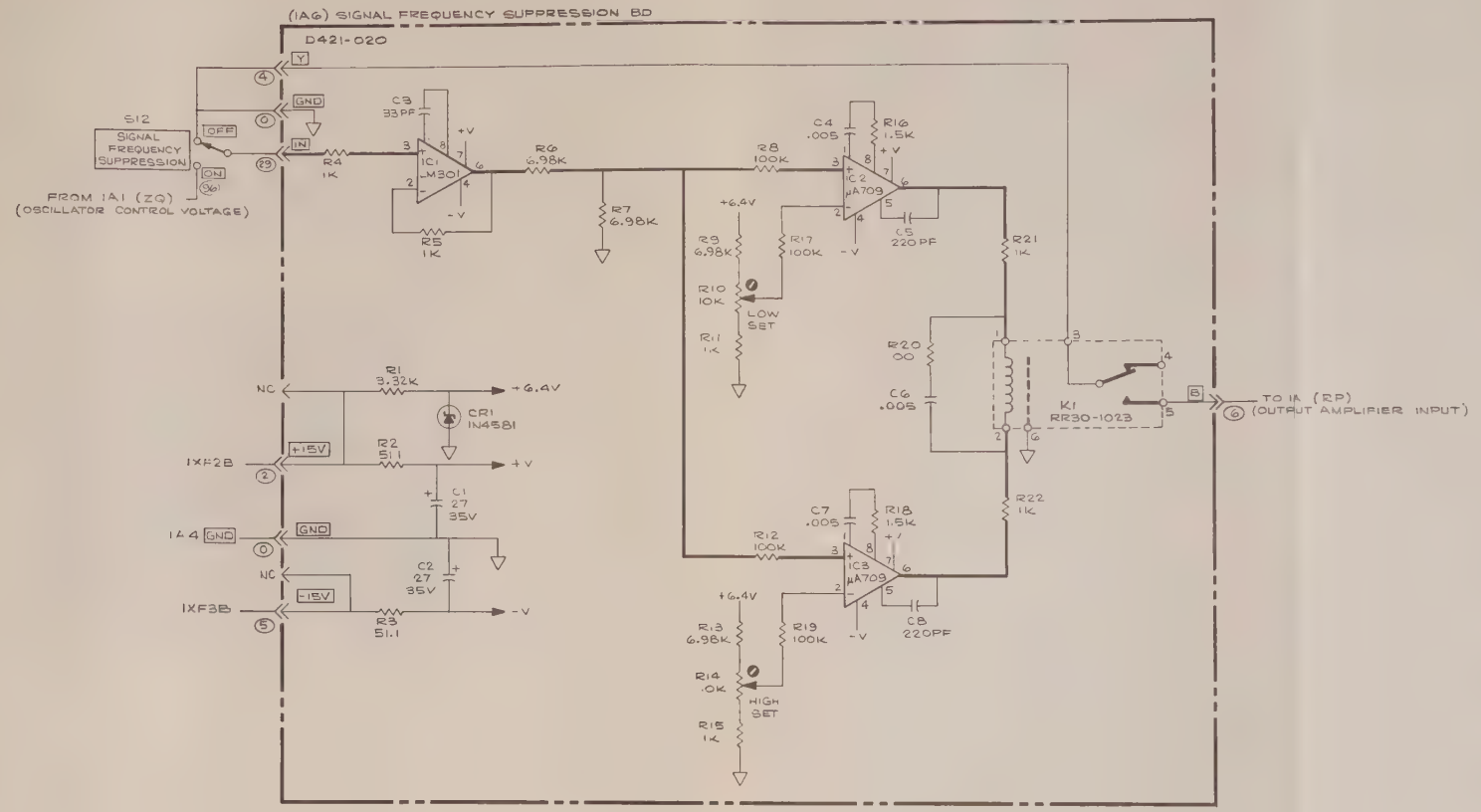

LAST REFERENCE DESIGNATIONS USED

CAPACITORS	C8
DIODES	CR1
INTEGRATED CIRCUITS	IC3
RELAYS	K1
RESISTORS	R22

2. ALL CAPACITOR VALUES ARE IN MICROFARADS (µf).
1. ALL RESISTOR VALUES ARE IN OHMS (Ω).

NOTE UNLESS OTHERWISE SPECIFIED

REV	ECN	BY	DATE	APP

REMOVE ALL BURRS AND BREAK SHARP EDGES
MATERIAL
FINISH WAVETEK PROCESS
DRAWN B. REDMAN DATE 5-6-14
RELEASE APPROV
TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ± 1° XX ± .030
DO NOT SCALE DWG
SCALE

WAVETEK SAN DIEGO, CALIFORNIA

SCHEMATIC DIAGRAM, SIGNAL FREQUENCY SUPPRESSION BD (1A6)

MODEL NO 421
DWG NO D421-220
REV
CODE IDENT 23338
SHEET 1 OF 1

D421-22C

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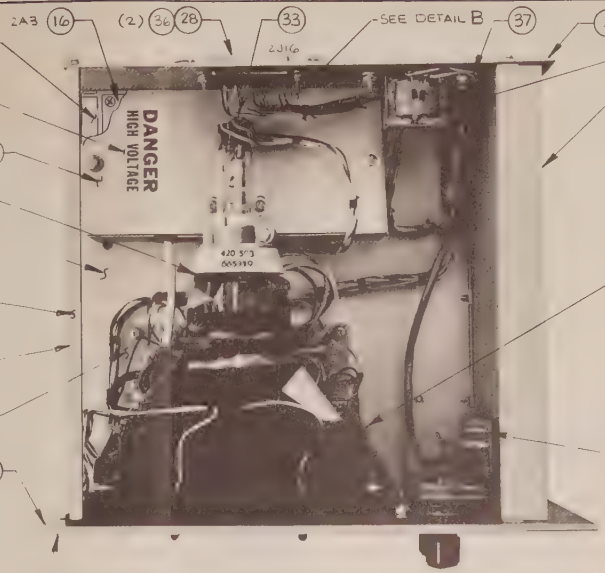
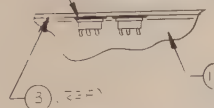
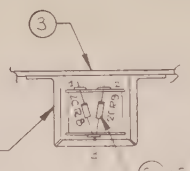
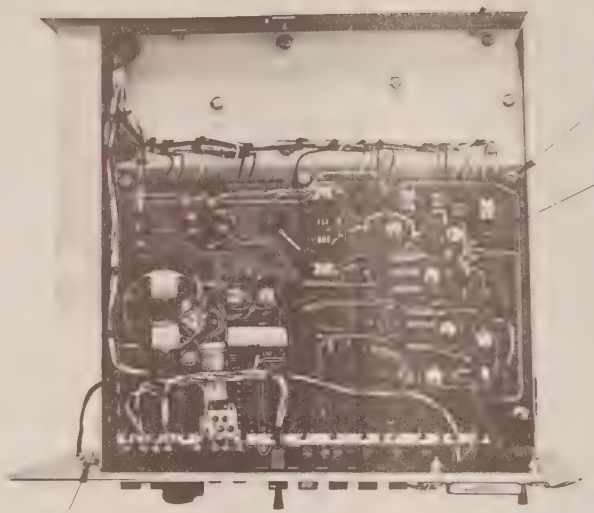


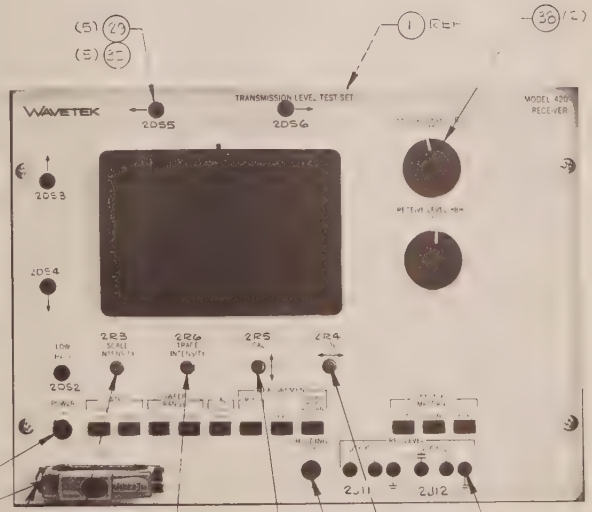


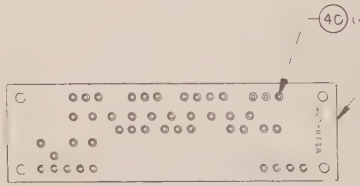
DETAIL B



DETAIL A





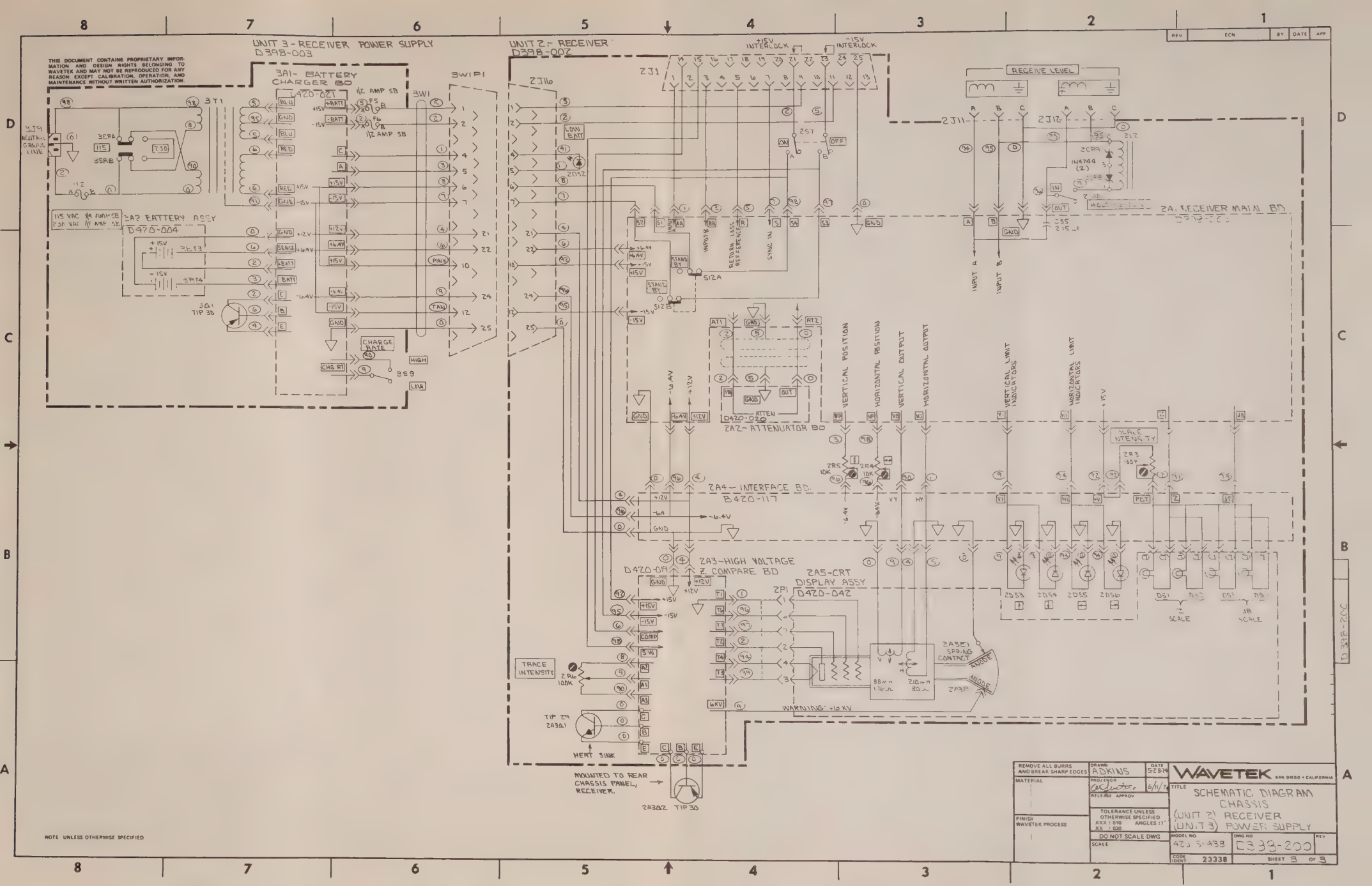


DETAIL C

. ALL LOCK WASHERS MUST BE SPRING (SPLIT) LOCK TYPE.

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B. REDMAN	DATE 6/13/74	WAVETEK SAN DIEGO • CALIFORNIA
MATERIAL	PROJENGR		TITLE ASSEMBLY, RECEIVER (UNIT 2)
FINISH WAVETEK PROCESS	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ± 1 XX ± .030		
	DO NOT SCALE DWG		MODEL NO 420-S-438 DWG NO 0398-002 REV
	SCALE		CAGE IDENT 23338 SHEET 1 OF 2


UNIT 3 - RECEIVER POWER SUPPLY
D398-003
UNIT 2 - RECEIVER
D398-002
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3A1- BATTERY CHARGER BD
D420-021
3T1
3CR1
3SR1
3A2 BATTERY ASSY
D420-004
3W1
3W1P1
3Q1
TIP 30
3S1
CHARGE RATE
HIGH
LOW
2J1
2J11
2J12
2J116
2S1
ON
OFF
LOW BATT
2DS2
2A1 RECEIVER MAIN BD
D398-100
INPUT A
INPUT B
INPUT
RETURN (ASSY REFERENCE)
SYNC IN
STAND BY
2S2A
2S2B
2A2- ATTENUATOR BD
D420-020
ATTEN
VERTICAL POSITION
HORIZONTAL POSITION
VERTICAL OUTPUT
HORIZONTAL OUTPUT
VERTICAL LIMIT INDICATORS
HORIZONTAL LIMIT INDICATORS
SCALE INTENSITY
2R3
2A4 - INTERFACE BD.
D420-117
2A3-HIGH VOLTAGE Z COMPARE BD
D420-09
2A5-CRT DISPLAY ASSY
D420-042
2P1
2A5E1 SPRING CONTACT
ANODE
2A5P
TRACE INTENSITY
2R16
100K
WARNING: +6 KV
2A3Q1
TIP 29
HEAT SINK
MOUNTED TO REAR CHASSIS PANEL, RECEIVER.
2A3Q2 TIP 30
2CR9
1N4744 (2)
2DS3
2DS4
2DS5
2DS6
DS1
DS2
DS3
DS4
SCALE
JR SCALE
NOTE UNLESS OTHERWISE SPECIFIED
REMOVE ALL BURRS AND BREAK SHARP EDGES
MATERIAL
FINISH
WAVETEK PROCESS
DRAWN ADKINS
DATE 5/28/74
PROJ ENGR
RELEASE APPROV
6/1/74
TOLERANCE UNLESS OTHERWISE SPECIFIED
XXX ± .010 ANGLES ±1°
XX ± .030
DO NOT SCALE DWG
SCALE
WAVETEK SAN DIEGO • CALIFORNIA
TITLE
SCHEMATIC DIAGRAM CHASSIS (UNIT 2) RECEIVER (UNIT 3) POWER SUPPLY
MODEL NO 421 & 438
DWG NO D398-200
REV
CODE IDENT 23338
SHEET 3 OF 3
D398-200

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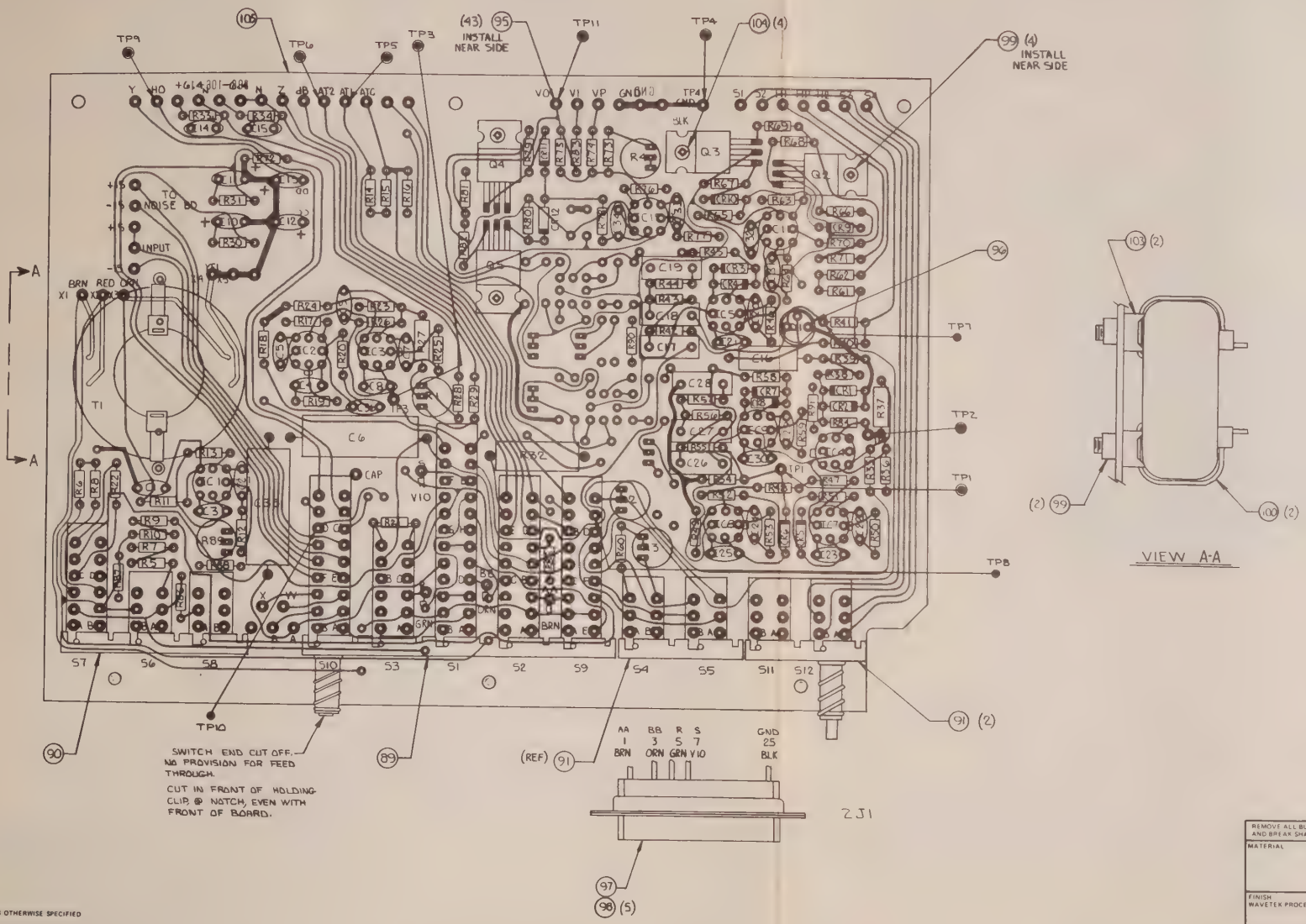
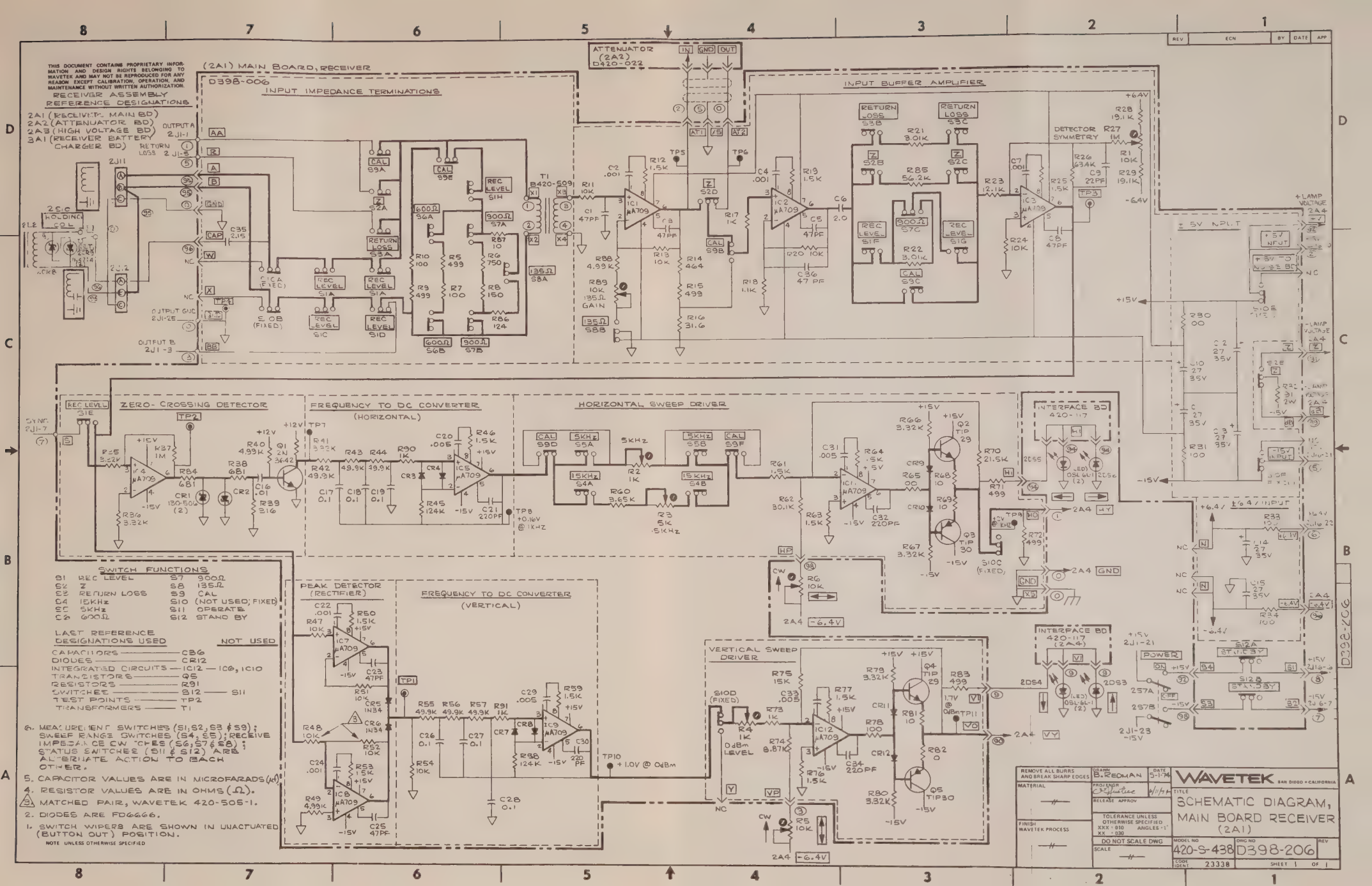
REV	ECN	BY	DATE	APP



NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN BARRETT	DATE 3-20-74	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	PROJ ENGR	4/25/74	TITLE ASSEMBLY- MAIN BOARD (2A1) RECEIVER
FINISH WAVETEK PROCESS	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ± 1 XX .030		
	DO NOT SCALE DWG		MODEL NO 420-S-438 DWG NO D398-0006 REV
	SCALE 2/1		CODE IDENT 23338 SHEET 1 OF 2

D398-0006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RECEIVER ASSEMBLY REFERENCE DESIGNATIONS
2A1 (RECEIVER MAIN BD)
2A2 (ATTENUATOR BD)
2A3 (HIGH VOLTAGE BD)
3A1 (RECEIVER BATTERY CHARGER BD)
(2A1) MAIN BOARD, RECEIVER
D398-006
INPUT IMPEDANCE TERMINATIONS
ATTENUATOR (2A2) D420-022
INPUT BUFFER AMPLIFIER
ZERO-CROSSING DETECTOR
FREQUENCY TO DC CONVERTER (HORIZONTAL)
HORIZONTAL SWEEP DRIVER
PEAK DETECTOR (RECTIFIER)
FREQUENCY TO DC CONVERTER (VERTICAL)
VERTICAL SWEEP DRIVER
INTERFACE BD 420-117
INTERFACE BD 420-117 (2A4)
± 5V NPUT
SWITCH FUNCTIONS
S1 REC LEVEL
S2 Z
S3 RETURN LOSS
S4 15KHz
S5 5KHz
S6 600Ω
S7 900Ω
S8 135Ω
S9 CAL
S10 (NOT USED; FIXED)
S11 OPERATE
S12 STAND BY
LAST REFERENCE DESIGNATIONS USED
NOT USED
CAPACITORS — C36
DIODES — CR12
INTEGRATED CIRCUITS — IC12 — IC6, IC10
TRANSISTORS — Q5
RESISTORS — R91
SWITCHES — S12 — S11
TEST POINTS — TP2
TRANSFORMERS — T1
6. MEASUREMENT SWITCHES (S1, S2, S3 & S9); SWEEP RANGE SWITCHES (S4, S5); RECEIVE IMPEDANCE CW CHES (S6, S7 & S8); STATUS SWITCHES (S11 & S12) ARE ALTERNATE ACTION TO EACH OTHER.
5. CAPACITOR VALUES ARE IN MICROFARADS (μf).
4. RESISTOR VALUES ARE IN OHMS (Ω).
3. MATCHED PAIR, WAVETEK 420-505-1.
2. DIODES ARE FD6666.
1. SWITCH WIPERS ARE SHOWN IN UNACTUATED (BUTTON OUT) POSITION.
NOTE UNLESS OTHERWISE SPECIFIED
REMOVE ALL BURRS AND BREAK SHARP EDGES
MATERIAL
FINISH WAVETEK PROCESS
DRAWN B. KEOMAN
DATE 5-1-74
PROJ. ENGR
RELEASE APPROV
TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± 010 ANGLES ±1° XX ± 030
DO NOT SCALE DWG
SCALE
WAVETEK SAN DIEGO, CALIFORNIA
TITLE
SCHEMATIC DIAGRAM, MAIN BOARD RECEIVER (2A1)
MODEL NO 420-S-438
DWG NO D398-206
REV
CODE IDENT 23338
SHEET 1 OF 1
D398-206

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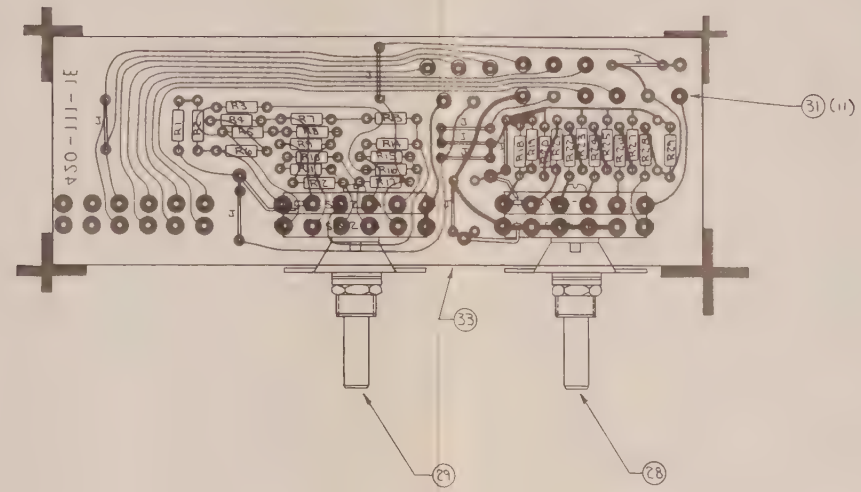
REV	ECN	BY	DATE	APP



NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN ADKINS	DATE 6-6-74	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	PROJENGR	6/5/74	TITLE ASSEMBLY ATTENUATOR (2A2) RECEIVER
	RELEASE APPROV		
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ± 1 XX ± .030		
	DO NOT SCALE DWG	MODEL NO 420	DWG NO D 420-022 REV
	SCALE 2/1	CODE IDENT 23338	SHEET 1 OF 2

BRUNING 40-330 15821

D420-022

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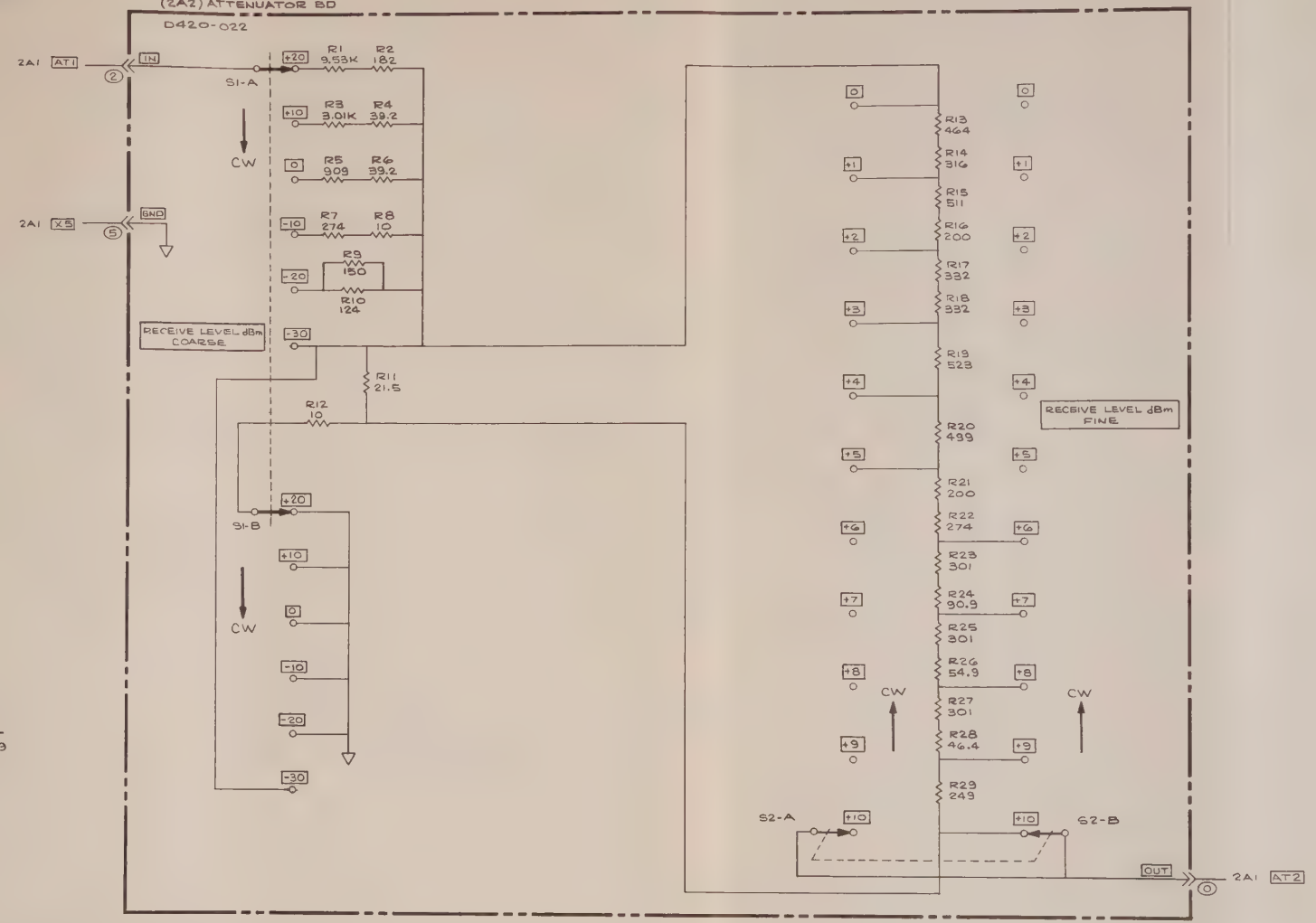
REV	ECN	BY	DATE	APP



LAST REFERENCE DESIGNATIONS USED

RESISTORS —— R29

SWITCHES —— S2

2. ROTARY SWITCHES (S1 & S2) ARE SHOWN FULLY CCW AS VIEWED FROM KNOB END OF SHAFT.
1. ALL RESISTOR VALUES ARE IN OHMS (Ω).

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B. REDMAN	DATE 5-3-74	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	PROJ ENGR	6/11/74	TITLE: SCHEMATIC DIAGRAM, ATTENUATOR BD (2A2) RECEIVER
FINISH WAVETEK PROCESS	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ± 1 XX ± .030		MODEL NO 420
	DO NOT SCALE DWG		DWG NO D420-222 REV
	SCALE		CODE IDENT 23338 SHEET 1 OF 1

D420-222

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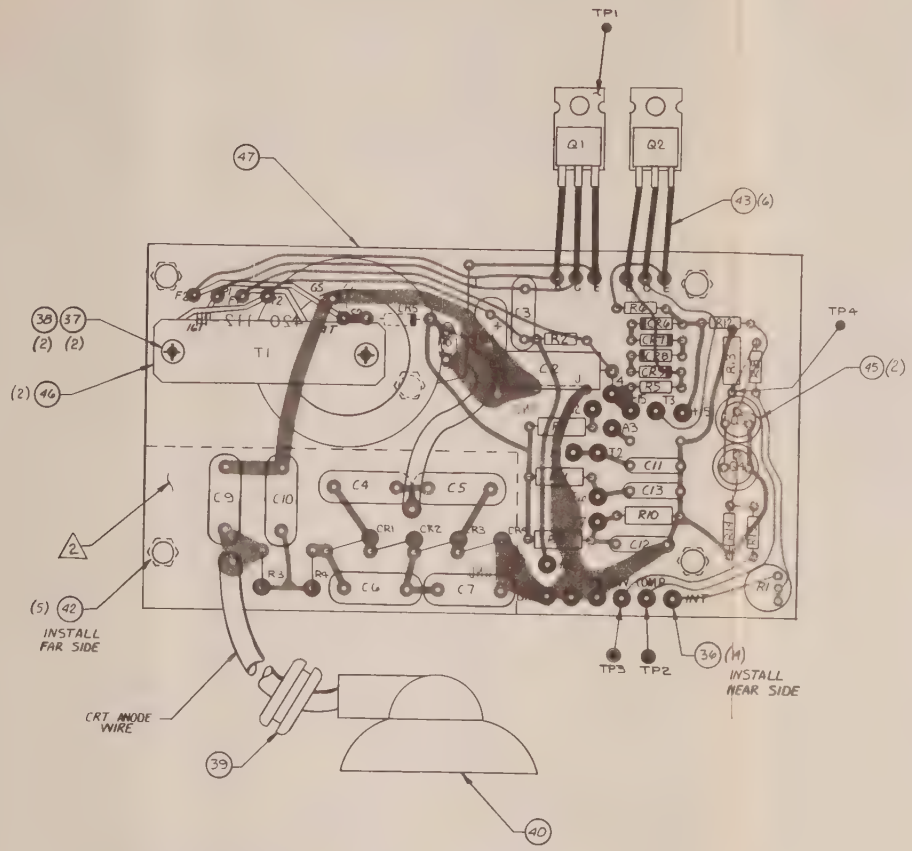
REV	ECN	BY	DATE	APP
A	CHANGED P/N DIODES	B.A.	6-28-78	
B	REVISED P/N'S	B.R.	7/5/78	



SIDE VIEW

R3, R4, AND CR1 THRU CR4 ARE TO BE MOUNTED ON END DIODES ARE MOUNTED WITH ANODE UP.

2 APPLY SILICON RUBBER (ITEM 41) TO INDICATED AREA. MINIMUM THICKNESS 1/16" ON BOTH SIDES OF CIRCUIT BOARD. ENCAPSULATE ALL COMPONENTS. HEAVY BUILD UP REQUIRED AT BASE OF 6KV OUTPUT (CRT ANODE WIRE).

1 R5 VALUE TO BE SELECTED AT TEST (15K TO 30.1K) FOR 70ma DC I5ma WITH A CRT BEING POWERED BY THIS BOARD.

NOTE UNLESS OTHERWISE SPECIFIED

OPTION C

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN D. BARNETT	DATE 3-15-78	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	PROJECTION		TITLE ASSEMBLY — HIGH VOLTAGE SUPPLY (2A3) RECEIVER
FINISH WAVETEK PROCESS	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ± 1 XX ± .030		
	DO NOT SCALE DWG		MODEL NO 420 DWG NO D420-019 REV B
	SCALE 2/1		CODE IDENT 23338 SHEET 1 OF 2

D420-019 B

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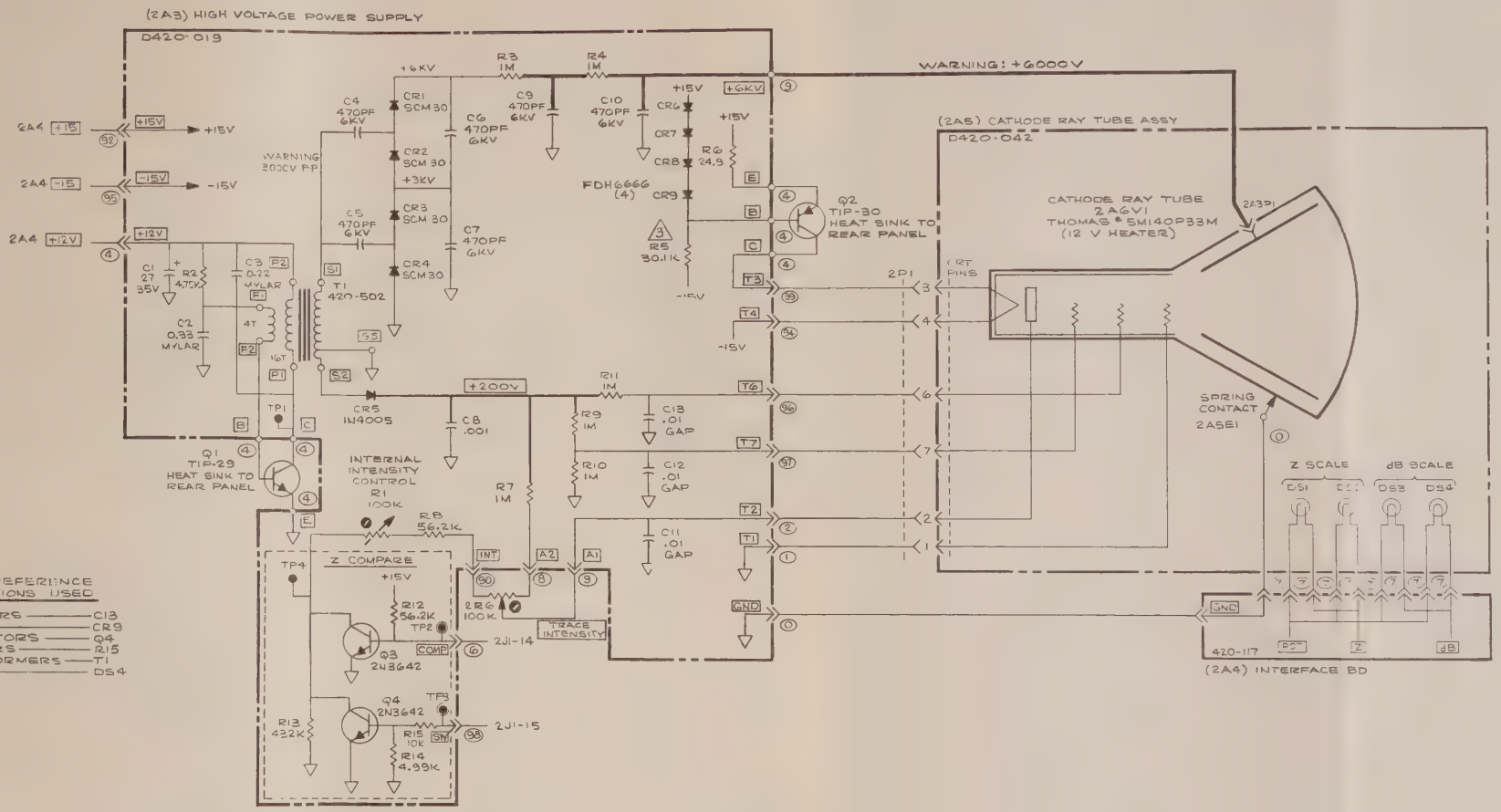
REV	ECN	BY	DATE	APP
A	ADDED NOTE 3	BA	4/24	



LAST REFERENCE DESIGNATIONS USED

CAPACITORS	C13
DIODES	CR9
TRANSISTORS	Q4
RESISTORS	R15
TRANSFORMERS	T1
LAMPS	DS4

⚠5 RE VALUE TO BE SELECTED @ TEST (15K TO 30.1K) FOR 70mA DC ±7mA WITH A CRT BEING POWERED BY THIS BOARD.

2. ALL CAPACITOR VALUES ARE IN MICROFARADS (μf).

1. ALL RESISTOR VALUES ARE IN OHMS (Ω).

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B. REDMAN	DATE 5-7-74	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	PROJ MGR		TITLE SCHEMATIC DIAGRAM, HIGH VOLTAGE/Z COMPARE BD (2A3) RECEIVER
FINISH WAVETEK PROCESS	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ±.010 ANGLES ±1 XX ±.030		MODEL NO 420
	DO NOT SCALE DWG		DWG NO D420-219 REV A
	SCALE		CODE IDENT 23338 SHEET 1 OF 1

D420-219

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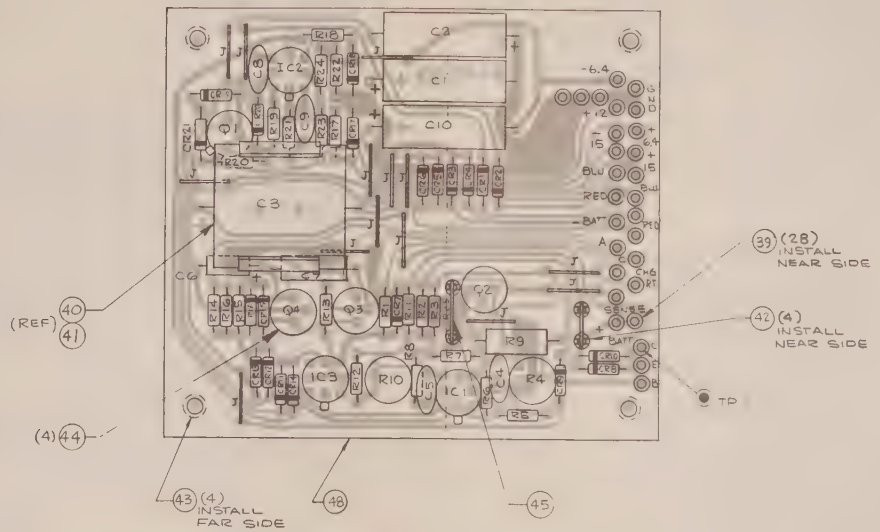
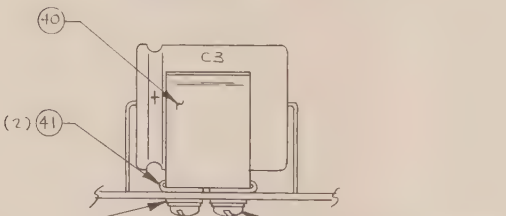
REV	ECN	BY	DATE	APP
C	ECN 732 773	[illegible]	[illegible]	[illegible]
D	ECN 911	DM	5-1-74	[illegible]
E	ECN 934	[illegible]	[illegible]	[illegible]
F	ECN 951	[illegible]	[illegible]	[illegible]





C3 MTG DETAIL

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN BOCHICHIO	DATE 5-15-73
MATERIAL	PROJ ENGR [illegible]	6/24/74
	RELEASE APPROV	
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ± 1° XX ± .030	
	DO NOT SCALE DWG	
	SCALE 2:1	

WAVETEK SAN DIEGO • CALIFORNIA

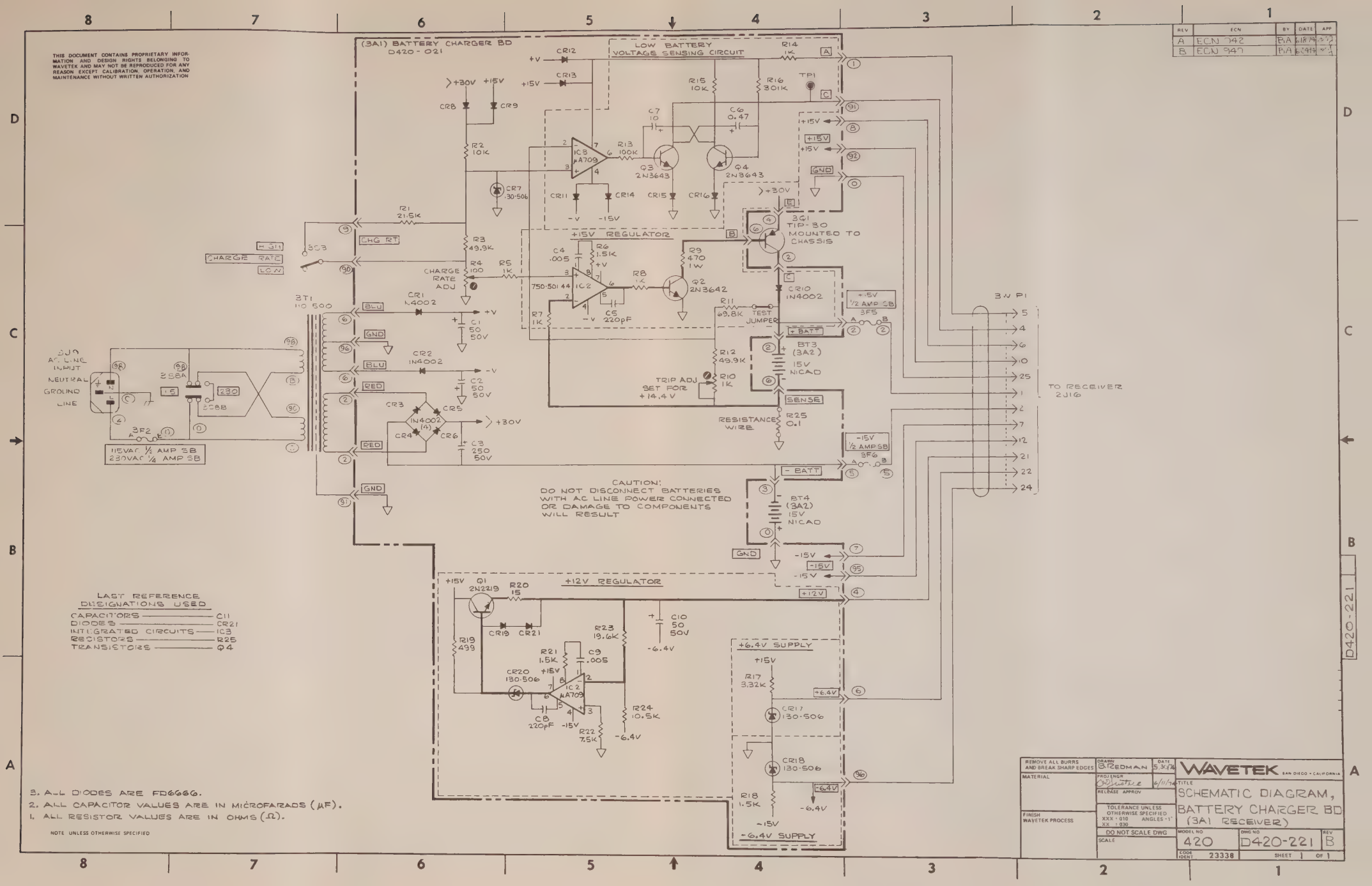
TITLE: ASSEMBLY BATTERY CHARGER BD (3A1) RECEIVER

MODEL NO 420 | DWG NO D420-021 | REV F

CODE IDENT 23338 | SHEET 1 OF 2

D420-021 F

BRUNING 40-520 15621



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REV	ECN	BY	DATE	APP
A	ECN 942	BA	6/8/74	
B	ECN 947	BA	6/27/74	

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B. REDMAN	DATE 5/3/74	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	PROJ ENGR	6/11/74	TITLE SCHEMATIC DIAGRAM, BATTERY CHARGER BD (3A1 RECEIVER)
FINISH WAVETEK PROCESS	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ±1° XX ± .030		
	DO NOT SCALE DWG		MODEL NO 420 DWG NO D420-221 REV B
	SCALE		CODE IDENT 23338 SHEET 1 OF 1

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   Page 6-3, Transmission Testing Considerations
   Appendix B, Return Loss Balance Theory and Terminal Balance Tests

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   Section 6 Page 20, Terminal Balance and Toll Connecting Trunk Design

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   Page 6-30, Figures 17, 18, and 19, Typical Arrangements of Trunks and Station Lines.
   Page 6-34, Balance Requirements in Two-Wire Switching Centers

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   Engineering Director -- Data Communications -- March 1969
   American Telephone and Telegraph Co., New York, N. Y.
   (Bell System Data Communications Technical Reference No. 41004)

BELL SYSTEM PRACTICES

B.S.P. No.	Title
300-300-503	Completion Tests of Exchange Area Cables —— Testing
330-450-100	Fault Location Using VF Sweep Tests —— General Theory
330-450-101	Fault Location Using VF Sweep Tests —— Trunk Cable Parts
330-450-102	Fault Location Using VF Sweep Tests —— Subscriber Cable Pairs
330-450-507	Fault Location Using VF Sweep Tests —— Detailed Analysis
330-300-901PT	Toll and Trunk Cables, Acceptance Tests —— Expected Test Results (Published by the Pacific Tel. and Tel. Co., San Francisco)

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